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# ASSESSMENT OF INDUSTRIAL HAZARDOUS WASTE PRACTICES - ELECTRONIC COMPONENTS MANUFACTURING INDUSTRY

WAPORA, INCORPORATED, WASHINGTON, D. C.

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# ASSESSMENT OF INDUSTRIAL HAZARDOUS WASTE PRACTICES -- ELECTRONIC COMPONENTS MANUFACTURING INDUSTRY

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This report describes hazardous waste generation and management in the electronic components manufacturing industry, defined as those plants whose primary products are components intended for assembly into electronic equipment. The Standard Industrial Classification (SIC) of the industry is 367. Twenty-three plant surveys showed that product and manufacturing process diversity within the industry precludes satisfactory correlation of these factors with waste types. Based upon the plant survey data, land-disposed wastes of the industry fall into ten waste categories including five categories which are both land-disposed in quantifyable amounts and contain hazardous materials (halogenated solvents, non-halogenated solvents, wastewater treatment sludges, painting wastes, and hydraulic and lubricating oils), and five categories which included either unquantifyable amounts of hazardous materials, no hazardous materials or were not typically land-filled (metal scrap, concentrated cyanides, concentrated acids and alkalies, plastic wastes, and miscellaneous). Isolated occurrences of beryllium- and PCB-containing wastes were recognized. Hazardous properties of the industry's land-disposed wastes include flammability, corrosivity/dermal irritation, oral toxicity, and bioconcentration. Constituents of the wastes which had these properties were non-halogenated solvents, various heavy metals, flourides, and oils. The estimated total quantity of potentially hazardous wastes land-disposed by the industry in 1975 was 49,500 kkg (54,500 tons) on a wet weight basis of which more than half was wastewater treatment sludges. With the exceptions of some halogenated and non-halogenated solvents which are segregated and reclaimed and of occasional on-site disposal of oils and wastewater treatment sludges, most potentially hazardous wastes (87 percent) generated by surveyed plants were ultimately land-disposed off-site by private contractors. The best technology currently applied and the technology required to provide environmentally adequate treatment for each waste stream and attendant costs are discussed.

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Hazardous Wastes
Wastewater treatment sludges
Solvents
Oils
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Disposal and treatment costs

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Special expression of appreciation is extended to the 23 electronic components manufacturing companies and their personnel who voluntarily participated in this Assessment.

TABLE OF CONTENTS

Section Page

I EXECUTIVE SUMMARY . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 1

INTRODUCTION . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 1
PROJECT METHODOLOGY . . . . . . . . . . . . . . . . . . . . . . . . . 1
MAJOR FINDINGS OF THE STUDY . . . . . . . . . . . . . . . . . . . . . 5

Description of the Industries . . . . . . . . . . . . . . . . . . 5
Waste Characterization . . . . . . . . . . . . . . . . . . . . . . 6
Waste Stream Quantification . . . . . . . . . . . . . . . . . . . 9
Treatment and Disposal Technology . . . . . . . . . . . . . . . . 16
Costs of Treatment and Disposal . . . . . . . . . . . . . . . . . 19

II DESCRIPTION OF THE ELECTRONIC COMPONENTS MANUFACTURING INDUSTRY . . . . 23

INTRODUCTION . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 23
PRODUCTS OF THE INDUSTRIES . . . . . . . . . . . . . . . . . . . . . 23
ECONOMIC STRUCTURE . . . . . . . . . . . . . . . . . . . . . . . . . 24
GEOGRAPHIC DISTRIBUTION OF PLANTS . . . . . . . . . . . . . . . . . 26
EMPLOYMENT . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 30
GEOGRAPHIC DISTRIBUTION OF PRODUCTION . . . . . . . . . . . . . . . 35
ECONOMIC TRENDS . . . . . . . . . . . . . . . . . . . . . . . . . . . 36

III WASTE CHARACTERIZATION . . . . . . . . . . . . . . . . . . . . . . . . 45

INTRODUCTION . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 45
CRITERIA FOR THE DETERMINATION OF A POTENTIALLY HAZARDOUS WASTE . . 49

Toxicity . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 50
Flammability . . . . . . . . . . . . . . . . . . . . . . . . . . . 51

DEFINITION OF POTENTIALLY HAZARDOUS WASTE STREAMS . . . . . . . . . . 51

Sampling Techniques and analytical methods . . . . . . . . . . . 52

WASTE GENERATION: RAW MATERIALS, MANUFACTURING PROCESSES AND WASTE SOURCES . . . . . . . . . . . . . . . . . . . . . . . . 53

RAW MATERIALS . . . . . . . . . . . . . . . . . . . . . . . . . . 54

Metals . . . . . . . . . . . . . . . . . . . . . . . . . . . . 58
Metal Salts . . . . . . . . . . . . . . . . . . . . . . . . . 58
Metal Oxides and Carbonates . . . . . . . . . . . . . . . . . 60
Glass . . . . . . . . . . . . . . . . . . . . . . . . . . . . 62
Plastics . . . . . . . . . . . . . . . . . . . . . . . . . . . 63
Paints and Organic Coatings . . . . . . . . . . . . . . . . . 63
Oils . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 64
Halogenated Solvents . . . . . . . . . . . . . . . . . . . . . 64
Non-chlorinated Solvents . . . . . . . . . . . . . . . . . . . 66
Acids and Alkalies . . . . . . . . . . . . . . . . . . . . . . 66
Miscellaneous Raw Materials . . . . . . . . . . . . . . . . . 66

MANUFACTURING PROCESSES AND PROCESS WASTES . . . . . . . . . . . 68

Solvent Cleaning . . . . . . . . . . . . . . . . . . . . . . . 69
Sawing and Cutoff . . . . . . . . . . . . . . . . . . . . . . . 71

**Section** **Page**

Baking . . . 71
Acid Cleaning and Etching . . . 72
Electroplating . . . 72
Dry Booth Painting . . . 73
Vacuum Metalizing . . . 73
Thermoforming Plastics . . . 74
Casting Plastics . . . 74
Grinding, Polishing and Lapping . . . 74
Non-plastic molding . . . 75
Frit Salvaging . . . 75
Phosphor Deposition . . . 75
Cyanide Clenaing of Metals . . . 75

Process Flow Diagrams . . . 76

NATURE OF PROCESS WASTES . . . 78

INTRODUCTION . . . 78
WASTE CATEGORIES . . . 84

Halogenated Solvents . . . 84
Nonhalogenated Solvents . . . 86
Wastewater Treatment Sludges . . . 88
Plastics . . . 91
Hydraulic and Cutting Oils . . . 93
Paint Wastes . . . 94

IDENTIFICATION OF POTENTIALLY HAZARDOUS WASTE STREAMS . . . 94

Halogenated Solvents . . . 97
Nonhalogenated Solvents . . . 98
Wastewater Treatment Sludges . . . 98
Plastics . . . 98
Hydraulic and Cutting Oils . . . 98
Paint Wastes . . . 98

QUANTITIES OF PROCESS WASTE STREAMS . . . 99

DATA BASE . . . 99
TOTAL WASTE GENERATED . . . 100
QUANTIFICATION OF POTENTIALLY HAZARDOUS WASTES AND HAZARDOUS CONSTITUENTS OF THE WASTE STREAM . . . 103

Halogenated Solvents . . . 103
Nonhalogenated Solvents . . . 103
Wastewater Treatment Sludges . . . 103
Plastics . . . 104
Paint Wastes . . . 104

PROJECTED CHANGES IN WASTE GENERATION . . . 104
EFFECTS OF PUBLIC LAW 92-500 ON THE WASTEWATER TREATMENT SLUDGE WASTE STREAMS . . . 105

SUMMARY OF THE WASTE STREAM QUANTIFICATIONS . . . 108

IV TREATMENT AND DISPOSAL TECHNOLOGY . . . 111

INTRODUCTION . . . 111

Section Page

LANDFILL . . . 111
SECURED LANDFILL . . . 112
INCINERATION . . . 112
RECLAMATION . . . 112

DESCRIPTION OF PRESENT WASTE HANDLING AND TREATMENT TECHNOLOGY . . . 112
DESCRIPTION OF PRESENT TREATMENT AND DISPOSAL TECHNOLOGY . . . 115
ON-SITE VS. OFF-SITE TREATMENT AND DISPOSAL . . . 116
PRIVATE CONTRACTORS AND SERVICE ORGANIZATIONS . . . 117
WASTE GENERATION AND DISPOSAL TECHNOLOGY FOR AN AVERAGE PLANT . . . 118
SAFEGUARDS USED IN DISPOSAL . . . 119
LEVELS OF TREATMENT AND DISPOSAL TECHNOLOGY FOR POTENTIALLY HAZARDOUS WASTE STREAMS . . . 121

V COST ANALYSIS . . . 129

INTRODUCTION . . . 129
TREATMENT AND DISPOSAL COSTS . . . 130

LEVEL I TECHNOLOGY . . . 130

Halogenated Solvents . . . 130
Nonhalogenated Solvents . . . 130
Wastewater Treatment Sludge . . . 131
Lubricating and Hydraulic Oils . . . 131
Paint Wastes . . . 131

LEVEL II TECHNOLOGY . . . 131

Halogenated Solvents . . . 132
Nonhalogenated Solvents . . . 132
Wastewater Treatment Sludges . . . 132
Lubricating and Hydraulic Oils . . . 132
Paint Wastes . . . 133

LEVEL III TECHNOLOGY . . . 133

Halogenated Solvents . . . 133
Nonhalogenated Solvents . . . 133
Wastewater Treatment Sludges . . . 134
Lubricating and Hydraulic Oils . . . 134
Paint Wastes . . . 134

IMPACT OF POTENTIALLY HAZARDOUS WASTES MANAGEMENT COSTS TO THE INDUSTRY . . . 134

TREATMENT AND DISPOSAL COSTS AT AN AVERAGE PLANT . . . 137

VI REFERENCES . . . 142

VII GLOSSARY . . . 145

# LIST OF APPENDICES

Appendix
A PRODUCTS OF THE ELECTRONIC COMPONENTS MANUFACTURING INDUSTRY, SIC 367
B WASTE GENERATION VOLUMES FOR THE ELECTRONIC COMPONENTS MANUFACTURING INDUSTRY
C METHODOLOGY
D PRIVATE WASTE CONTRACTORS AND SERVICE ORGANIZATIONS

## LIST OF TABLES

| Table | Title | Page |
|---|---|---|
| I-1 | Four-digit SIC Categories in the Electronic Components Manufacturing Industry, Number of Plants in the Categories, Number of Plants Surveyed and Percent Surveyed. | 4 |
| I-2 | Process Waste Categories which are Land Disposed by the Electronic Components Manufacturing Industry and their Hazardous Properties or Constituents. | 8 |
| I-3 | Electronic Components Manufacturing, SIC 367, Process Waste Generation, 1975, State and EPA Region Totals (kkg/year) | 11 |
| I-4 | Electronic Components Manufacturing, SIC 367, Process Waste Generation, 1977, State and EPA Region Totals (kkg/year) | 12 |
| I-5 | Electronic Components Manufacturing, SIC 367, Process Waste Generation, 1983, State and EPA Region Totals (kkg/year) | 13 |
| I-6 | Summary of Treatment and Disposal Methods Provided for the Five Potentially Hazardous Waste Streams of the Electronic Components Manufacturing under the Three Technology Levels | 18 |
| I-7 | Estimated Potentially Hazardous Waste Treatment and Disposal Costs | 20 |
| I-8 | Treatment and Disposal Costs for Potentially Hazardous Wastes at an Average Electronic Components Manufacturing Plant by Waste Stream and Treatment and Disposal Technology Level | 21 |
| II-1 | Economic Data for the Four-digit SIC categories in the Electronic Components Manufacturing Industry | 25 |
| II-2 | Total Value of Shipments for Product Groups in SIC 3679 | 27 |
| II-3 | Product Mix in the Electronic Components Industry as shown by Primary Product Specialization Ratio and Coverage Ratio | 28 |
| II-4 | SIC 367 Electronic Components Manufacturing Industry--Geographic Distribution of Plants | 29 |
| II-5 | Employment Size of Establishments | 31 |
| II-6 | SIC 367, Electronic Components Manufacturing -- Distribution of Plant Size by Employment, State, and EPA Region | 32 |
| II-7 | Employee to Value of Shipment Ratios for the Four-digit SIC's - Electronic Components Values in terms of Number of Employees Per Million Dollars | 39 |

LIST OF TABLES (CONTINUED)

| Table | Title | Page |
|---|---|---|
| II-8 | Value of Shipments for the Nation, EPA Region and States by Four-digit SIC and the Industry | 40 |
| II-9 | Average Value of Shipments Per Plant for the 10 States with Largest Production | 41 |
| II-10 | Estimates of Four-digit SIC Production levels for 1975, 1976, 1977, and 1983 as measured by value of shipments | 42 |
| III-1 | Electronic Components Manufacturing, SIC 367, Process Waste Generation, 1975, National Totals | 46 |
| III-2 | Electronic Components Manufacturing, SIC 367, Process Waste Generation, 1977, National Totals | 47 |
| III-3 | Electronic Components Manufacturing, SIC 367, Process Waste Generation, 1983, National Totals | 48 |
| III-4 | Distribution of Surveyed Plants by Geographic Location Census Regions and EPA Regions | 55 |
| III-5 | Raw Materials in Electronic Components Manufacturing | 56 |
| III-6 | Metal Plating Processes, Bath Constituents and Concentrations of Constituents in the Electronic Components Industry | 59 |
| III-7 | Composition of Cathode Ray Tube Phosphors | 61 |
| III-8 | Non-Chlorinated Solvents Used in Surveyed Plants, Their Flash Points and Threshold Limit Values | 67 |
| III-9 | Manufacturing Processes used in Surveyed Electronic Components Plants | 70 |
| III-10 | Process Wastes Generated by Manufacturing Processes in the Electronic Components Manufacturing Industry | 77 |
| III-11 | Chemical Analysis of Halogenated Solvent Wastes from Electronic Component Manufacturing Plants | 87 |
| III-12 | Chemical Analysis of Non-Halogenated Solvent Wastes from Electronic Component Manufacturing Plants | 89 |
| III-13 | Chemical Analysis of Wastewater Treatment Sludges from Electronic Component Manufacturing Plants | 92 |
| III-14 | Chemical Analysis of Oil-containing Wastes from Electronic Components Manufacturing Plants | 95 |

LIST OF TABLES (CONTINUED)

| Table | Title | Page |
|---|---|---|
| III-15 | Chemical Analysis of Paint Wastes from Electronic Components Manufacturing Plants | 96 |
| III-16 | Ratios of 1977 and 1983 Value of Industry Shipments to 1975 Value of Industry Shipments | 106 |
| IV-1 | 1975 Plant Production, Employment, Number of Plants, Waste Stream Generation Rates and Level I Disposal Technology for the Electronic Components Manufacturing Industry and for an average Plant | 120 |
| IV-2 | Treatment and Disposal of Halogenated Solvents | 123 |
| IV-3 | Treatment and Disposal of Non-Halogenated Solvents | 124 |
| IV-4 | Treatment and Disposal of Wastewater Treatment Sludges | 125 |
| IV-5 | Treatment and Disposal of Lubricating and Hydraulic Oils | 126 |
| IV-6 | Treatment and Disposal of Paint Wastes | 127 |
| V-1 | Estimated Potentially Hazardous Waste Treatment and Disposal Costs | 135 |
| V-2 | Total National Costs to the Electronic Components Manufacturing Industry for Potentially Hazardous Waste Treatment and Disposal | 136 |
| V-3 | SIC 367 Profitability, 1975 Total Profits, and Comparisons between Total Profits and Potentially Hazardous Waste Treatment and Disposal Costs | 138 |
| V-4 | Treatment and Disposal Costs for Potentially Hazardous Wastes at an Average Electronic Components Manufacturing Plant by Waste Stream and Disposal Technology Level | 139 |
| V-5 | Average Plant Costs for Treatment and Disposal, 1975, SIC - 367 Electronic Components Manufacturing Industry | 140 |
| C-1 | Chemical Analysis of Miscellaneous Waste Samples | C-5 |

## LIST OF FIGURES

| Figure | Title | Page |
|---|---|---|
| II-1 | Number of SIC 367 Plants in Each State | 38 |
| II-2 | Value of Industry Shipments - SIC 367 in Current Dollars and in 1967 Dollars | 43 |
| III-1 | Example Process Flow Diagram, Integrated Circuits, SIC 3674 | 79 |
| III-2 | Example Process Flow Diagram, Electron Tubes, SIC 3673 | 80 |
| III-3 | Example Process Flow Diagram, Electronic Connectors, SIC 3678 | 81 |
| III-4 | Example Process Flow Diagram, Magnetic Tape, SIC 3679 | 82 |
| III-5 | Example Process Flow Diagram, Complex Components, SIC 3679 | 83 |

# SECTION I

## EXECUTIVE SUMMARY

### INTRODUCTION

This study is an assessment of the hazardous waste management practices of the industry establishments which manufacture electronic components, Standard Industrial Classification (SIC) 367. It is one of a series of industrial studies initiated by the Office of Solid Waste, Hazardous Waste Management Division, of the U.S. Environmental Protection Agency (EPA). The studies have been conducted for information purposes only and not in response to a Congressional regulatory mandate. As such, the studies serve to provide EPA with: (1) an initial data base on current and projected types and quantities of industrial wastes, applicable treatment and disposal techniques and their associated costs; (2) a data base for technical assistance activities; and (3) a background for guidelines development work.

The definition of "potentially hazardous waste" used in this study is based upon contractor investigations and the assessment of wastes generated by SIC 367 plants exclusively. This definition does not reflect final EPA judgement since any Agency definition must be broadly applicable to a wide range of different types and combinations of wastes. Some of the criteria for a hazardous designation applied to this report make use of numerical limitations designed initially for other environmental control purposes, and all of the criteria are based entirely on information available to the contractor at this time. The reader is cautioned that the validity of these criteria for this purpose rests on many unknown or partially understood factors and that the criteria should be subject to review when mechanisms to illustrate actual effects of wastes in specified environments become available.

This report describes the SIC 367 industry in terms of plant distribution by geographic region, size, employment, and products; analyzes the types of total and potentially hazardous wastes generated and estimates their present and projected quantities; and discusses the various methods currently used to treat and dispose of these waste streams and those alternative methods needed to treat, dispose, or reuse each waste stream in an environmentally adequate manner. The costs of both present and alternative treatment and disposal practices were estimated based on data collected during plant surveys and information published in other EPA reports (1-4, 33, 37,39).

### PROJECT METHODOLOGY

Standard Industrial Classifications were used to develop and compare information on the product areas within SIC 367, their production, and wastes. The statistical description of the industry and the product areas as defined by four-digit SICs presented in Section II was developed primarily from U.S. Bureau of the Census and other U.S. Department of Commerce data, along with Dun & Bradstreet directories and computer printouts. Where data were not available - for example, in states that have less than three plants in a product area - contractor assumptions were applied. Published statistics and contractor estimates were used to project to 1983 value of shipments in each of the product areas.

The mechanism used primarily to characterize the wastes of these industries was on-site surveys of representative plants. 1972 Census of Manufacturers [5] data was the initial source of information for selection of plants to be visited. Dun & Bradstreet Marketing Services for Manufacturers, 1975 [6] provided names, addresses and products of manufacturers and was used to select companies for contact to request approval of plant visits. Twenty-two plants were visited and one other plant provided data for this study. Plants visited were distributed: (1) geographically in proportion to the number of SIC 367 plants present in the four Department of Commerce Census Regions and (2) on the basis of product manufactured in proportion to value of shipments in each four-digit SIC.

The most difficult problem encountered in the conduct of this study was obtaining permission for plant visits. Over two hundred plants listed by Dun & Bradstreet [6] were selected for contact on the basis of geographical location and primary product manufactured. Responsible personnel in these plants were contacted by telephone to request their voluntary participation in the study. Substantive reasons given for not allowing plant visits generally fall into four catagories:

- production technology was the basis of the company's competitive posture and had to be protected.

- economic conditions had caused employee layoffs and as a result, the remaining personnel had become burdened with too many responsibilities to be able to grant the time required for the plant survey.

- employment, production, material usage and/or waste generation data were considered trade secrets which could be extrapolated by competitors into plant operations information, outside knowledge of which could be detrimental to the company.

- it was company policy not to voluntarily participate in any outside surveys.

The frequency with which the first three reasons listed were cited support literature descriptions of the industry [10] as being highly competitive and technologically turbulent.

The contractor has made every effort to verify the plant data collected during the survey and to protect plant data under the provisions of the U.S. Freedom of Information Act (40).

The twenty-three surveyed plants were distributed among the nine four-digit SIC categories of the industry as shown in Table I-1. More recent data on the electronic components manufacturing industry as a whole [10] indicates that the number of industry plants dropped to 2,500 in 1975 so that the 23 plants surveyed actually represent 0.92 percent of the industry. However, the total 1975 value of shipments from surveyed operations represents 3.6 percent of the industry.

The small number of plants surveyed in each SIC category precludes reporting some types of data gathered from the plant visits since trade secrets could thereby be disclosed. The small number of plants visited in each SIC category similarly precludes identification of and quantification of "typical" process flow diagrams for any four-digit SIC category. Lack of uniformity in process flow and raw material usage among the four-digit SIC categories prevents meaningful designation of a typical process flow diagram for the electronic components industry as a whole. This lack of uniformity among the SIC categories is accented by several examples of completely dissimilar process flows between plants within the same SIC category.

During the plant visits, seventeen waste samples were collected. These samples were subsequently analyzed for properties or chemical constituents considered, after a preliminary literature search, to be of consequence in quantifying the waste streams and in the designation of wastes as potentially hazardous. Sample parameters used in quantifying wastes were drying loss of solids at 103°C, ignition loss of solids at 550°C, solids at 550°C and percent water. Sample parameters used in assessing the hazardous nature of the wastes were flash point, oil and grease (hexane extractables), pH, cadmium, chromium, copper, iron, lead, zinc, fluoride and trichloroethylene. The samples represented six waste categories as listed below.

| Waste Type | Number of Samples |
|---|---|
| Halogenated Solvents | 2 |
| Non-halogenated Solvents | 3 |
| Wastewater Treatment Sludges | 3 |
| Oils | 2 |
| Paint Wastes | 2 |
| Miscellaneous | 5 |

Table I-1

Four-digit SIC Categories in the Electronic Components Manufacturing Industry, Number of Plants in the Categories Number of Plants Surveyed and Percent Surveyed.

| | | | Number of Plants° | Plants Surveyed | Percent Surveyed |
|---|---|---|---|---|---|
| SIC | 3671 | Electron Tubes, Receiving Type | 25 | 0 | -- |
| | 3672 | Cathode Ray Television Picture Tubes | 75 | 2 | 2.7 |
| | 3673 | Electron Tubes, Transmitting | 53 | 3 | 5.7 |
| | 3674 | Semiconductors & Related Devices | 325 | 5 | 1.5 |
| | 3675 | Electronic Capacitors | 113 | 1 | 0.9 |
| | 3676 | Electronic Resistors | 86 | 2 | 2.3 |
| | 3677 | Electronic Coils & Transformers | 246 | 1 | 0.4 |
| | 3678 | Electronic Connectors | 92 | 2 | 2.2 |
| | 3679 | Electronic Components, Not Elsewhere Classified | 1,840 | 7 | 0.4 |
| | | | 2,855 | 23 | 0.8 |

°Source: 1972 Census of Manufacturers [5]

Information obtained at the plants and in the literature was used to describe the various manufacturing processes employed, raw materials used and the sources and nature of process wastes. The plant surveys also provided information on quantities of wastes generated by product area. Waste generation data and value of shipments or employment data provided by the plants were used in conjunction with Census information on value of shipments to estimate national volumes of significant waste streams generated by the industry in 1975. Using published forecasts of industry production and contractor assumptions, the 1975 waste quantities were projected to 1977 and 1983 taking into consideration the effects of water pollution control legislation on waste generation to land-disposal. The estimated production of electronic components per state, as measured by value of shipments, was used to disaggregate the national waste quantities by state and EPA Region.

Throughout the waste quantification steps, it was assumed that waste generation within any one product area would be proportional to plant production as measured by value of shipments. Value of shipments was the only type of data available from both plants and industry-wide literature that could serve as a basis for supportable assumptions about waste generation.

Most of the cost data on the treatment and disposal of process wastes from the electronic components manufacturing industry were obtained during the survey visits. These data were supplemented by information provided in literature sources. Since Level III technology (defined in the "Treatment and Disposal Practices" Section) has generally not been implemented by the industry as yet, cost estimates for this technology as it applies to various waste streams were developed from other studies (33, 37, 39).

## MAJOR FINDINGS OF THE STUDY

### Description of the Industries

SIC 367, Electronic Components Manufacturing, includes eight specific product areas identified by four-digit SIC's and one four-digit SIC that covers everything not classified in the first eight. This latter four-digit SIC, 3679, covers 34.6 percent of the industry on the basis of value of shipments and 64.4 percent on the basis of number of plants. The four-digit industry classifications are listed in Table I-1.

According to the 1972 Census of Manufacturers, there were 2,855 establishments in the industry. Total employment was 334,500. All of the states and the District of Columbia have electronic component plants except Alaska, Montana, North Dakota and Wyoming. Six states, California, New York, New Jersey, Illinois, Massachusetts and Pennsylvania, have over 100 plants each and, together, have 64 percent of the plants and 66 percent of the production as measured by value of shipments.

In terms of constant 1967 dollars, the total value of shipments for the industry increased from $7.5 million in 1967 to $8.5 million in 1972.

Estimates of total values of shipments made for 1975, 1977 and 1983 are $9.0, $10.7 and $15.7 million, respectively, indicating continued growth in the industry. The most rapidly growing product area is SIC 3674 - Semiconductors, which includes transistors, diodes and more recently developed integrated circuits. Declining production is occurring in SIC 3671 - Electron Tubes - Receiving Type, SIC 3675 - Capacitors, and SIC 3676 - Resistors. Displacement of these devices by semiconductors is the apparent cause of their decline.

## Waste Characterization

Due to a high degree of design diversity within product areas, wastes of the industry are categorized by the primary constituent of wastes, not by raw material usage or manufacturing process. Ten categories of process wastes were recognized in surveyed plants:

- Halogenated Solvents
- Non-halogenated Solvents
- Wastewater Treatment Sludges
- Plastics
- Oils
- Paint Wastes
- Metal Scrap
- Concentrated Cyanides
- Concentrated Acids and Alkalies
- Miscellaneous process wastes

All of these categories, except plastics, contain wastes which would be considered potentially hazardous according to the definition of potentially hazardous wastes used in this report. However, metal scrap, concentrated cyanides, and concentrated acids and alkalies are not land-disposed in significant quantities by the industry. Metal scrap, except beryllium oxide wastes, is nearly always sold to metal reclaimers. The cyanides, acids and alkalies are typically oxidized and neutralized by conventional methods of wastewater treatment and produce no residue for land disposal. Only one of the twenty-three surveyed plants land disposed of concentrated cyanides or acids. The only hazardous waste recognized in the miscellaneous category was one containing polychlorinated biphenyls. (This waste is considered atypical of the product area in which it is generated, resistors. In addition, its use in this product is being discontinued.) The manufacturer's company did not specify the material which will replace the use of PCB's. The term "waste stream" is used here to denote the other six process waste categories which are typically land disposed.

The waste streams classified as potentially hazardous either manifest one or more toxic characteristics, or are flammable. No biological, radioactive, or explosive wastes are generated in SIC 367.

The toxic characteristics include corrosivity/dermal irritation, bioconcentration, and toxicity. The latter term is used to mean the range of toxic effects not included in the other manifestations.

Wastes with a flash point of 38°C (100°F) or below [U.S. Department of Transportation (41) ] are considered potentially hazardous because of their flammability.

Thus, the criteria for hazardousness used in this report are as follows:

| Hazard | Criteria |
|---|---|
| Flammability | Flashpoint less than 38°C (100°F) (41) |
| Corrosivity/dermal irritation | pH less than 5.0 or greater than 9.0 |
| Toxicity | Raw waste leachate from a waste contains a constituent exceeding maximum contaminant level of Federal Water Quality Criteria [14] |
| Bioconcentration | Contains cadmium, lead, mercury, or PCB in any detectable concentration |

The wastes of these industries necessitate these broad criteria. In some cases, a hazardous constituent accounts for the bulk of the waste stream or is the only component. In others, hazardous constituents account for a much smaller portion of the total waste stream, but are distributed throughout and cannot be segregated in waste handling.

Of the ten process waste categories recognized in surveyed plants that are typically landfilled, all except plastics had at least one occurrence of a property or chemical constituent which is considered to be hazardous under the above criteria. The process waste categories are listed in Table I-2 and their hazardous properties or constituents are identified. These process waste categories are not inclusive of all of the wastes generated by the electronic components manufacturing industry. Dilute acids, dilute cyanides, furnace and oven gasses and some wastewater constituents are not expected to be land disposed. In addition, portions of all the identified waste streams, except perhaps paint wastes and plastics, are either recovered (solvents, metals), are disposed of by gaseous emissions (solvents, paint wastes), end up in wastewater effluents instead of being converted to wastewater treatment sludges (dissolved and particulate metals, fluorides, solvents, oils) or are destroyed (cyanides, acids, and alkalies). Discussion and quantification of these process waste categories is limited to those portions which were destined for land disposal from surveyed plants. Detailed quantification, including estimation of 1975 national waste totals, estimation of hazardous constituent quantities, disaggregation of national waste and constituent totals to EPA Region and state quantity estimates, and projection of estimated 1975 quantities to 1977 and 1983, is applied only to potentially hazardous process waste streams which are generated and land-disposed in significant quantities, hereafter referred to as "waste streams". These "waste streams" are the land-disposed portions (and/or recycled in the case of halogenated and non-halogenated solvents) of the following process waste categories:

Table I-2

Process Waste Categories which are Land Disposed by the Electronic Components Manufacturing Industry and their Hazardous Properties or Constituents.

| Process Waste Category | Flammability | pH | Toxicity | Bioconcentration |
|---|---|---|---|---|
| Halogenated Solvents[1] | Not Flammable | within range-pH 5-6 | Narcotic concentrations could occur in enclosed storage areas. Combustion in landfill could generate highly toxic gases. Can contain oils and heavy metal impurities (cadmium, lead, zinc and chromium found in samples analyzed) | Could contain lead and cadmium. |
| Non-Halogenated Solvents[1] | Most are Flammable | Two of three samples collected were outside pH 5-9 range. | Narcotic concentrations could occur in enclosed Storage areas. Can contain oils and heavy metal impurities (chromium, copper, lead and zinc found in samples analyzed) | Could contain lead and cadmium. |
| Wastewater Treatment Sludges[1] | Not Flammable | Potential exists for pH 9.0 but three samples collected were between pH 5 & 9. | Can contain any of the toxic impurities noted for other wastestreams plus fluorides. | Could contain lead and cadmium. |
| Plastics[2] | Not Flammable | Not applicable | The only potential toxicant discovered in the plastics category was chromium oxide bound to recording tapes. Leaching of chromium oxide from waste tape is judged to be unlikely. More research may be required on this possibility. | None |
| Oils[1] | Not Flammable | Not expected to be a significant problem. One sample had a pH of 4.8. | Contains oil and heavy metal impurities (cadmium, chromium, copper, lead and zinc found in samples analyzed). | Could contain lead and cadmium. |
| Paint Wastes[1] | Half of these wastes are estimated to be flammable. | Not expected to be a significant problem. One sample had a pH of 4.5. | Contains solvents which could produce narcotic concentrations in enclosed storage areas. Contains heavy metal impurities (lead, zinc, and chromium found in samples analyzed). | Could contain lead. |
| Metal Scrap[3] | Not Flammable | Not applicable | Beryllium metal and beryllium oxide wastes. | None |
| Concentrated Cyanide[4] | Not Flammable | pH above 9.0 | Contains high concentrations of cyanide and any or all of the heavy metals. | Could contain lead and cadmium. |
| Concentrated Acids & Alkalies[4] | Not Flammable | pH above 9 or below 5. | Can contain heavy metals, oils, small amounts of solvents and fluorides. | Could contain lead and cadmium. |
| Miscellaneous[2] | Not Flammable | Not Applicable | The only potentially hazardous waste that fits this category is atypical for the industry and contains polychlorinated biphenyls. | One process waste contains polychlorinated biphenyls. |

[1] These process waste categories contain potentially hazardous wastes that are land-disposed in significant quantities and are, therefore, considered potentially hazardous waste streams.

[2] The plastics and miscellaneous process waste category is considered to be non-hazardous.

[3] The only hazardous process waste in the metal scrap category are small quantities of beryllium metal, beryllium oxide and associated clean-up materials. These wastes are hazardous but are segregated from other metal scrap wastes, most of which are recycled. Metal scrap is considered to be non-hazardous.

[4] Concentrated cyanides, acids and alkalies are definitely hazardous wastes. However, only one surveyed plant land disposed of these process wastes on land. The hazardous properties and constituents of these process wastes are usually chemically altered (pH, cyanide) or removed as a sludge in wastewater treatment (dissolved and particulate metals, oils and solvents).

- Halogenated Solvents
- Non-halogenated Solvents
- Wastewater Treatment Sludges
- Oils
- Paint Wastes

Single examples of land-disposal for concentrated cyanides, concentrated acids and the miscellaneous waste category (a bag-house residue containing polychlorinated biphenyls) were seen in surveyed plants. Two plants land-disposed of beryllium metal and/or beryllium oxide wastes. These wastes have hazardous constituents and are discussed in detail, but there is insufficient data on these process wastes to warrant detailed quantification.

## Waste Stream Quantification

The only index of production useful for converting waste quantities reported in surveyed plants to three- and four-digit industry waste quantities was value of shipments. Because of a lack of comparability between product categories in waste generation, plant waste quantity data was extrapolated to product area quantities (four-digit SIC's, except for SIC 3679 - Electronic Components, Not Elsewhere Classified, where six-digit SIC's were used) using the ratio of plant waste quantities to plant 1975 value of shipments and multiplying by the SIC's 1975 value of product shipments [10]. Product area waste stream volumes thus obtained were added by waste stream across product areas to obtain total waste stream quantities for those portions of the industry represented by surveyed plants.

Products representing thirty-five percent of the value of product shipments in the electronic components manufacturing industry were not included in surveyed plants. Product area that were not surveyed fall into three categories:

- Nineteen percent of the industry is represented by seventeen product areas in SIC 3679 which individually have small proportions of the industry production

- One percent of the industry is represented by SIC 3671, a previously important segment of the industry. No SIC 3671 plants would agree to participate in the survey.

- Fifteen percent of the industry value of shipments is produced in miscellaneous product categories which are too small to be identified in Census data [5, 10].

It is the contractor's opinion that plant surveys in these three categories would reveal process waste types and waste disposal practices not recognized in the 23 plant surveys completed to date. However, the typical process waste categories in the unsurveyed 35 percent of the industry are assumed to be similar in composition and generation rate to the typical process waste categories for the surveyed portion of the industry. Therefore, total waste quantities developed from plant data and product area value of shipments are multiplied by $\frac{100}{65} = 1.54$ to estimate industry-wide process waste quantities. Where less than three examples of land-disposal for a process waste category (concentrated cyanides, concentrated acids and alkalies) or individual potentially hazardous process wastes (bag-house residue containing PCB, beryllium wastes), the results of quantification are not reported in order to protect the confidentiality of data provided voluntarily by private businesses. The total land disposed quantities of these particular process wastes are negligible in relation to other process waste quantities.

For the six process waste categories which are land disposed in significant quantities, Tables I-3, I-4, and I-5 give the combined total process waste quantities, potentially hazardous waste quantities and hazardous constituent quantities for the electronic components manufacturing industry for 1975, 1977 and 1983, respectively. Total and potentially hazardous waste quantities are presented as both wet and dry weights in kilo-kilograms per year (kkg/year) Dry weight refers only to the non-aqueous portion of the process wastes. Wet weight includes the weight of water in the wastes. The totals presented in Tables I-3, I-4, and I-5 are disaggregated by states and EPA Regions according to the percent of industry value of shipments attributed [5] to those jurisdictions. The national process waste totals for 1975, 1977 and 1983 are separately disaggregated by waste stream in Tables III-1, III-2, and III-3 (See Section III). Disaggregations by year, jurisdiction, and process waste category are provided in Appendix B.

Several points of interest can be made from estimates in the waste quantity tables:

- the five EPA Regions with the greatest quantities of total process wastes, potentially hazardous wastes, and hazardous constituents and their percentages of the national totals for these parameters are:

EPA Region II - 27.7 percent
EPA Region IX - 17.9 percent
EPA Region V - 16.9 percent
EPA Region I - 11.3 percent
EPA Region III - 11.1 percent

Five region total- 84.9 percent

- the five states with the greatest quantities of total process wastes, potentially hazardous wastes, and hazardous constituents and their percentages of the national totals are:

| | |
|---|---|
| New York | 22.2 percent |
| California | 16.8 percent |
| Pennsylvania | 8.6 percent |
| Massachusetts | 6.7 percent |
| Illinois | 6.6 percent |
| Five state total - | 60.9 percent |

(Since regional and state quantities were disaggregated on the basis of state value of shipments, the jurisdictional percentages are constant for all parameters.)

# TABLE I-3

## ELECTRONIC COMPONENTS MANUFACTURING
SIC 367
PROCESS WASTE GENERATION
1975 State and EPA Region Totals
(kkg/year)

| State | EPA Region | Total Waste (Wet Wt.) | Total Waste (Dry Wt.) | Total Potentially Hazardous Waste (Wet Wt.) | Total Potentially Hazardous Waste (Dry Wt.) | Total Hazardous Constituents (Dry Wt.) Flammable Solvents | Total Hazardous Constituents (Dry Wt.) Heavy Metals | Total Hazardous Constituents (Dry Wt.) Fluorides | Total Hazardous Constituents (Dry Wt.) Oils |
|---|---|---|---|---|---|---|---|---|---|
| ALABAMA | IV | 209. | 127. | 124. | 90. | 49. | .168 | 0. | .288 |
| ALASKA | X | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| ARIZONA | IX | 623. | 378. | 368. | 267. | 144. | .500 | 0. | .855 |
| ARKANSAS | VI | 299. | 182. | 177. | 128. | 69. | .240 | 0. | .411 |
| CALIFORNIA | IX | 10141. | 6155. | 5994. | 4341. | 2349. | 8.138 | 5. | 13.924 |
| COLORADO | VIII | 214. | 130. | 126. | 91. | 49. | .171 | 0. | .293 |
| CONNECTICUT | I | 1382. | 839. | 817. | 591. | 320. | 1.109 | 1. | 1.897 |
| DISTRICT OF COLUMBIA | III | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| DELAWARE | III | 160. | 97. | 95. | 69. | 37. | .129 | 0. | .220 |
| FLORIDA | IV | 2072. | 1257. | 1225. | 887. | 480. | 1.662 | 1. | 2.845 |
| GEORGIA | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| HAWAII | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| IDAHO | X | 387. | 235. | 229. | 166. | 90. | .311 | 0. | .532 |
| ILLINOIS | V | 3969. | 2409. | 2346. | 1699. | 919. | 3.185 | 2. | 5.450 |
| INDIANA | V | 2279. | 1383. | 1347. | 976. | 528. | 1.829 | 1. | 3.129 |
| IOWA | VII | 236. | 143. | 140. | 101. | 55. | .189 | 0. | .324 |
| KANSAS | VII | 90. | 54. | 53. | 38. | 21. | .072 | 0. | .123 |
| KENTUCKY | IV | 423. | 257. | 250. | 181. | 98. | .339 | 0. | .581 |
| LOUISIANA | VI | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MAINE | I | 361. | 219. | 213. | 154. | 84. | .289 | 0. | .495 |
| MARYLAND | III | 205. | 124. | 121. | 88. | 47. | .164 | 0. | .281 |
| MASSACHUSETTS | I | 4021. | 2440. | 2377. | 1721. | 931. | 3.227 | 2. | 5.521 |
| MICHIGAN | V | 398. | 241. | 235. | 170. | 92. | .319 | 0. | .546 |
| MINNESOTA | V | 1028. | 624. | 608. | 440. | 238. | .825 | 0. | 1.412 |
| MISSISSIPPI | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MISSOURI | VII | 248. | 150. | 146. | 106. | 57. | .199 | 0. | .340 |
| MONTANA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEBRASKA | VII | 268. | 163. | 159. | 115. | 62. | .215 | 0. | .368 |
| NEVADA | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW HAMPSHIRE | I | 522. | 317. | 309. | 224. | 121. | .419 | 0. | .717 |
| NEW JERSEY | II | 3356. | 2037. | 1984. | 1436. | 777. | 2.693 | 2. | 4.608 |
| NEW MEXICO | VI | 387. | 235. | 229. | 166. | 90. | .311 | 0. | .532 |
| NEW YORK | II | 13370. | 8115. | 7903. | 5723. | 3097. | 10.729 | 6. | 18.359 |
| NORTH CAROLINA | IV | 554. | 336. | 328. | 237. | 128. | .445 | 0. | .761 |
| NORTH DAKOTA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| OHIO | V | 2024. | 1229. | 1197. | 867. | 469. | 1.625 | 1. | 2.780 |
| OKLAHOMA | VI | 170. | 103. | 100. | 73. | 39. | .136 | 0. | .233 |
| OREGON | X | 104. | 63. | 61. | 45. | 24. | .083 | 0. | .143 |
| PENNSYLVANIA | III | 5174. | 3140. | 3058. | 2215. | 1199. | 4.152 | 2. | 7.105 |
| RHODE ISLAND | I | 388. | 236. | 229. | 166. | 90. | .311 | 0. | .533 |
| SOUTH CAROLINA | IV | 376. | 228. | 222. | 161. | 87. | .302 | 0. | .516 |
| SOUTH DAKOTA | VIII | 244. | 148. | 144. | 104. | 56. | .196 | 0. | .335 |
| TENNESSEE | IV | 143. | 87. | 85. | 61. | 33. | .115 | 0. | .196 |
| TEXAS | VI | 2026. | 1230. | 1197. | 867. | 469. | 1.626 | 1. | 2.782 |
| UTAH | VIII | 481. | 292. | 284. | 206. | 111. | .386 | 0. | .661 |
| VERMONT | I | 151. | 91. | 89. | 64. | 35. | .121 | 0. | .207 |
| VIRGINIA | III | 1050. | 637. | 621. | 449. | 243. | .842 | 0. | 1.442 |
| WASHINGTON | X | 92. | 56. | 54. | 39. | 21. | .074 | 0. | .126 |
| WEST VIRGINIA | III | 136. | 82. | 80. | 58. | 31. | .109 | 0. | .186 |
| WISCONSIN | V | 502. | 304. | 297. | 215. | 116. | .403 | 0. | .689 |
| WYOMING | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| TOTALS | | 60260. | 36575. | 35620. | 25795. | 13960. | 48.356 | 25. | 82.744 |
| REGION I | | 6824. | 4142. | 4034. | 2921. | 1581. | 5.476 | 3. | 9.370 |
| II | | 16726. | 10152. | 9887. | 7160. | 3875. | 13.422 | 8. | 22.967 |
| III | | 6724. | 4081. | 3975. | 2878. | 1558. | 5.396 | 3. | 9.233 |
| IV | | 3777. | 2293. | 2233. | 1617. | 875. | 3.031 | 2. | 5.187 |
| V | | 10200. | 6191. | 6029. | 4366. | 2363. | 8.185 | 5. | 14.005 |
| VI | | 2882. | 1749. | 1704. | 1234. | 668. | 2.313 | 1. | 3.957 |
| VII | | 842. | 511. | 498. | 360. | 195. | .676 | 0. | 1.156 |
| VIII | | 938. | 570. | 555. | 402. | 217. | .753 | 0. | 1.288 |
| IX | | 10764. | 6533. | 6362. | 4607. | 2494. | 8.637 | 5. | 14.790 |
| X | | 583. | 354. | 345. | 250. | 135. | .468 | 0. | .801 |

## Table I-4

ELECTRONIC COMPONENTS MANUFACTURING
SIC 367
PROCESS WASTE GENERATION
1977 State and EPA Region Totals
(kkg/year)

| State | EPA Region | Total Waste |  | Total Potentially Hazardous Waste |  | Total Hazardous Constituents (Dry Wt.) |  |  |  |
|---|---|---|---|---|---|---|---|---|---|
|  |  | (Wet Wt.) | (Dry Wt.) | (Wet Wt.) | (Dry Wt.) | Flammable Solvents | Heavy Metals | Fluorides | Oils |
| ALABAMA | IV | 317. | 170. | 271. | 125. | 62. | .351 | 0. | .397 |
| ALASKA | X | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| ARIZONA | IX | 942. | 506. | 806. | 371. | 184. | 1.043 | 1. | 1.180 |
| ARKANSAS | VI | 452. | 243. | 387. | 178. | 89. | .501 | 0. | .567 |
| CALIFORNIA | IX | 15332. | 8244. | 13129. | 6041. | 3001. | 16.975 | 10. | 19.209 |
| COLORADO | VIII | 323. | 174. | 276. | 127. | 63. | .357 | 0. | .404 |
| CONNECTICUT | I | 2089. | 1123. | 1789. | 823. | 409. | 2.313 | 1. | 2.617 |
| DISTRICT OF COLUMBIA | III | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| DELAWARE | III | 242. | 130. | 207. | 95. | 47. | .268 | 0. | .303 |
| FLORIDA | IV | 3132. | 1684. | 2682. | 1234. | 613. | 3.468 | 2. | 3.924 |
| GEORGIA | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| HAWAII | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| IDAHO | X | 586. | 315. | 502. | 231. | 115. | .648 | 0. | .734 |
| ILLINOIS | V | 6000. | 3226. | 5138. | 2364. | 1175. | 6.643 | 4. | 7.518 |
| INDIANA | V | 3446. | 1853. | 2951. | 1358. | 674. | 3.815 | 2. | 4.317 |
| IOWA | VII | 357. | 192. | 306. | 141. | 70. | .395 | 0. | .447 |
| KANSAS | VII | 136. | 73. | 116. | 53. | 27. | .150 | 0. | .170 |
| KENTUCKY | IV | 639. | 344. | 548. | 252. | 125. | .708 | 0. | .801 |
| LOUISIANA | VI | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MAINE | I | 545. | 293. | 467. | 215. | 107. | .604 | 0. | .683 |
| MARYLAND | III | 309. | 166. | 265. | 122. | 61. | .343 | 0. | .388 |
| MASSACHUSETTS | I | 6079. | 3269. | 5206. | 2395. | 1190. | 6.731 | 4. | 7.616 |
| MICHIGAN | V | 601. | 323. | 515. | 237. | 118. | .666 | 0. | .753 |
| MINNESOTA | V | 1554. | 836. | 1331. | 612. | 304. | 1.721 | 1. | 1.947 |
| MISSISSIPPI | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MISSOURI | VII | 375. | 201. | 321. | 148. | 73. | .415 | 0. | .469 |
| MONTANA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEBRASKA | VII | 406. | 218. | 347. | 160. | 79. | .449 | 0. | .508 |
| NEVADA | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW HAMPSHIRE | I | 790. | 425. | 676. | 311. | 155. | .874 | 1. | .989 |
| NEW JERSEY | II | 5073. | 2728. | 4344. | 1999. | 993. | 5.617 | 3. | 6.356 |
| NEW MEXICO | VI | 586. | 315. | 502. | 231. | 115. | .648 | 0. | .734 |
| NEW YORK | II | 20215. | 10869. | 17310. | 7965. | 3957. | 22.381 | 14. | 25.326 |
| NORTH CAROLINA | IV | 838. | 451. | 718. | 330. | 164. | .928 | 1. | 1.050 |
| NORTH DAKOTA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| OHIO | V | 3061. | 1646. | 2621. | 1206. | 599. | 3.389 | 2. | 3.835 |
| OKLAHOMA | VI | 257. | 138. | 220. | 101. | 50. | .284 | 0. | .322 |
| OREGON | X | 157. | 85. | 135. | 62. | 31. | .174 | 0. | .197 |
| PENNSYLVANIA | III | 7823. | 4206. | 6699. | 3082. | 1531. | 8.661 | 5. | 9.801 |
| RHODE ISLAND | I | 587. | 315. | 502. | 231. | 115. | .650 | 0. | .735 |
| SOUTH CAROLINA | IV | 568. | 305. | 486. | 224. | 111. | .629 | 0. | .712 |
| SOUTH DAKOTA | VIII | 368. | 198. | 315. | 145. | 72. | .408 | 0. | .462 |
| TENNESSEE | IV | 216. | 116. | 185. | 85. | 42. | .239 | 0. | .271 |
| TEXAS | VI | 3063. | 1647. | 2623. | 1207. | 600. | 3.391 | 2. | 3.837 |
| UTAH | VIII | 727. | 391. | 623. | 287. | 142. | .805 | 0. | .911 |
| VERMONT | I | 228. | 122. | 195. | 90. | 45. | .252 | 0. | .285 |
| VIRGINIA | III | 1587. | 853. | 1359. | 625. | 311. | 1.757 | 1. | 1.989 |
| WASHINGTON | X | 139. | 75. | 119. | 55. | 27. | .154 | 0. | .174 |
| WEST VIRGINIA | III | 205. | 110. | 175. | 81. | 40. | .227 | 0. | .257 |
| WISCONSIN | V | 758. | 408. | 649. | 299. | 148. | .840 | 1. | .950 |
| WYOMING | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| TOTALS |  | 91106. | 48987. | 78016. | 35897. | 17833. | 100.870 | 62. | 114.145 |
| REGION I |  | 10317. | 5548. | 8835. | 4065. | 2020. | 11.423 | 7. | 12.926 |
| II |  | 25288. | 13597. | 21655. | 9964. | 4950. | 27.998 | 17. | 31.683 |
| III |  | 10166. | 5466. | 8706. | 4006. | 1990. | 11.256 | 7. | 12.737 |
| IV |  | 5711. | 3071. | 4890. | 2250. | 1118. | 6.323 | 4. | 7.155 |
| V |  | 15421. | 8292. | 13205. | 6076. | 3018. | 17.073 | 10. | 19.320 |
| VI |  | 4357. | 2343. | 3731. | 1717. | 853. | 4.824 | 3. | 5.459 |
| VII |  | 1273. | 684. | 1090. | 501. | 249. | 1.409 | 1. | 1.595 |
| VIII |  | 1419. | 763. | 1215. | 559. | 278. | 1.571 | 1. | 1.777 |
| IX |  | 16273. | 8750. | 13935. | 6412. | 3185. | 18.017 | 11. | 20.388 |
| X |  | 882. | 474. | 755. | 347. | 173. | .976 | 1. | 1.105 |

# Table I-5

### ELECTRONIC COMPONENTS MANUFACTURING
### SIC 367
### PROCESS WASTE GENERATION
### 1983 State and EPA Region Totals
### (kkg/year)

| State | EPA Region | Total Waste |  | Total Potentially Hazardous Waste |  | Total Hazardous Constituents (Dry Wt.) |  |  |  |
|---|---|---|---|---|---|---|---|---|---|
|  |  | (Wet Wt.) | (Dry Wt.) | (Wet Wt.) | (Dry Wt.) | Flammable Solvents | Heavy Metals | Fluorides | Oils |
| ALABAMA | IV | 440. | 238. | 376. | 173. | 81. | .485 | 0. | .551 |
| ALASKA | X | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| ARIZONA | IX | 1308. | 707. | 1117. | 516. | 240. | 1.443 | 1. | 1.638 |
| ARKANSAS | VI | 628. | 339. | 537. | 248. | 115. | .693 | 0. | .786 |
| CALIFORNIA | IX | 21303. | 11507. | 18193. | 8397. | 3913. | 23.498 | 13. | 26.667 |
| COLORADO | VIII | 449. | 242. | 383. | 177. | 82. | .495 | 0. | .562 |
| CONNECTICUT | I | 2903. | 1568. | 2479. | 1144. | 533. | 3.202 | 2. | 3.634 |
| DISTRICT OF COLUMBIA | III | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| DELAWARE | III | 336. | 182. | 287. | 133. | 62. | .371 | 0. | .421 |
| FLORIDA | IV | 4352. | 2351. | 3717. | 1715. | 799. | 4.800 | 3. | 5.448 |
| GEORGIA | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| HAWAII | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| IDAHO | X | 814. | 440. | 695. | 321. | 149. | .898 | 0. | 1.019 |
| ILLINOIS | V | 8337. | 4503. | 7120. | 3286. | 1532. | 9.196 | 5. | 10.437 |
| INDIANA | V | 4788. | 2586. | 4089. | 1887. | 879. | 5.281 | 3. | 5.993 |
| IOWA | VII | 496. | 268. | 424. | 196. | 91. | .547 | 0. | .621 |
| KANSAS | VII | 188. | 102. | 161. | 74. | 35. | .208 | 0. | .236 |
| KENTUCKY | IV | 889. | 480. | 759. | 350. | 163. | .980 | 1. | 1.112 |
| LOUISIANA | VI | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MAINE | I | 758. | 409. | 647. | 299. | 139. | .836 | 0. | .948 |
| MARYLAND | III | 430. | 232. | 367. | 169. | 79. | .474 | 0. | .538 |
| MASSACHUSETTS | I | 8447. | 4562. | 7214. | 3329. | 1552. | 9.317 | 5. | 10.574 |
| MICHIGAN | V | 835. | 451. | 713. | 329. | 153. | .921 | 1. | 1.046 |
| MINNESOTA | V | 2159. | 1166. | 1844. | 851. | 397. | 2.382 | 1. | 2.703 |
| MISSISSIPPI | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MISSOURI | VII | 520. | 281. | 444. | 205. | 9[illegible]. | .574 | 0. | .652 |
| MONTANA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEBRASKA | VII | 564. | 304. | 481. | 222. | 104. | .622 | 0. | .706 |
| NEVADA | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW HAMPSHIRE | I | 1097. | 593. | 937. | 432. | 202. | 1.210 | 1. | 1.373 |
| NEW JERSEY | II | 7049. | 3808. | 6020. | 2778. | 1295. | 7.775 | 4. | 8.824 |
| NEW MEXICO | VI | 814. | 440. | 695. | 321. | 149. | .898 | 0. | 1.019 |
| NEW YORK | II | 28087. | 15171. | 23987. | 11071. | 5160. | 30.981 | 17. | 35.160 |
| NORTH CAROLINA | IV | 1165. | 629. | 995. | 459. | 214. | 1.285 | 1. | 1.458 |
| NORTH DAKOTA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| OHIO | V | 4253. | 2297. | 3632. | 1676. | 781. | 4.691 | 3. | 5.324 |
| OKLAHOMA | VI | 357. | 193. | 305. | 141. | 65. | .393 | 0. | .446 |
| OREGON | X | 219. | 118. | 187. | 86. | 40. | .241 | 0. | .274 |
| PENNSYLVANIA | III | 10869. | 5871. | 9282. | 4284. | 1997. | 11.989 | 7. | 13.606 |
| RHODE ISLAND | I | 815. | 440. | 696. | 321. | 150. | .899 | 0. | 1.020 |
| SOUTH CAROLINA | IV | 789. | 426. | 674. | 311. | 145. | .871 | 0. | .988 |
| SOUTH DAKOTA | VIII | 512. | 276. | 437. | 202. | 94. | .565 | 0. | .641 |
| TENNESSEE | IV | 300. | 162. | 257. | 118. | 55. | .331 | 0. | .376 |
| TEXAS | VI | 4256. | 2299. | 3634. | 1677. | 782. | 4.694 | 3. | 5.327 |
| UTAH | VIII | 1011. | 546. | 863. | 398. | 186. | 1.115 | 1. | 1.265 |
| VERMONT | I | 316. | 171. | 270. | 125. | 58. | .349 | 0. | .396 |
| VIRGINIA | III | 2205. | 1191. | 1883. | 869. | 405. | 2.433 | 1. | 2.761 |
| WASHINGTON | X | 193. | 104. | 165. | 76. | 35. | .213 | 0. | .241 |
| WEST VIRGINIA | III | 285. | 154. | 243. | 112. | 52. | .314 | 0. | .356 |
| WISCONSIN | V | 1054. | 569. | 900. | 415. | 194. | 1.162 | 1. | 1.319 |
| WYOMING | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| TOTALS |  | 126588. | 68376. | 108108. | 49896. | 23254. | 139.632 | 77. | 158.466 |
| REGION I |  | 14335. | 7743. | 12243. | 5650. | 2633. | 15.813 | 9. | 17.945 |
| II |  | 35136. | 18979. | 30007. | 13849. | 6454. | 38.757 | 21. | 43.985 |
| III |  | 14126. | 7630. | 12063. | 5568. | 2595. | 15.581 | 9. | 17.683 |
| IV |  | 7935. | 4286. | 6776. | 3128. | 1458. | 8.752 | 5. | 9.933 |
| V |  | 21426. | 11573. | 18298. | 8445. | 3936. | 23.634 | 13. | 26.822 |
| VI |  | 6054. | 3270. | 5170. | 2386. | 1112. | 6.678 | 4. | 7.579 |
| VII |  | 1768. | 955. | 1510. | 697. | 325. | 1.951 | 1. | 2.214 |
| VIII |  | 1971. | 1065. | 1683. | 777. | 362. | 2.174 | 1. | 2.467 |
| IX |  | 22611. | 12213. | 19310. | 8912. | 4154. | 24.941 | 14. | 28.305 |
| X |  | 1225. | 662. | 1046. | 483. | 225. | 1.351 | 1. | 1.533 |

- From Tables III-1, III-2 and III-3, the largest process waste category on a dry weight basis is the non-halogenated solvents waste stream, comprising an estimated 42 percent of the industry's total process wastes in 1975. Halogenated solvents and then wastewater treatment sludges follow non-halogenated solvents in quantity on a dry weight basis. It is the contractor's opinion that halogenated solvents are actually used in more operations than non-halogenated solvents, but ease of on-site recovery by distillation greatly reduces the quantity of halogenated solvent wastes.

- On a wet weight basis, wastewater treatment sludges is the largest waste stream for all years estimated. Between 1975 and 1977, the percentage of total process wastes attributable to wastewater treatment sludges increases from 46 percent to 56 percent. This increase relative to other waste streams would be the result of implementing the 1977 goal for best practicable control technology currently available (BPCTCA or BPT) for all electronic components manufacturing plants which have heavy metals, concentrated acids and alkalies and/or fluorides in their process wastewater. Estimation of the increase is confused somewhat by the fact that many of the manufacturing plants are located in urban areas where municipal sewerage is available to receive process wastewaters. Pretreatment standards for discharge to municipal sewers are not universally applicable even where process waste waters contain the pollutants relevant to this study. The estimated quantities of wastewater treatment sludges could, for this reason, be somewhat high.

- The effect on sludge quantities of implementing the 1983 goal for best available technology economically achievable (BATEA or BAT) is expected to be minimal. Available literature [7,8,9] predicts that technology required for wastewater treatment by 1983 will produce small increases in wastewater treatment residues over the 1977 quantities. Increases would only occur for those plants which discharge treated wastewaters to streams. The increase would largely be due to brines generated by evaporators or reverse osmosis.

- Increases in other waste stream quantities are expected to be directly related to increased industry production. No specific changes in wastes or in waste generating processes can be predicted from survey data or available literature. Considering the rate of product technology improvement that has occurred in the past thirty years, however, some shifts in waste stream types and quantities appear to be inevitable, if not predictable.

- Flammable solvents occur primarily in only two waste streams; non-halogenated solvents and paint wastes. Because of the widespread use of non-halogenated solvents, flammable solvents are by far the most abundant hazardous constituent of industry wastes.

- Various heavy metals are found in all of the industry's waste streams. Heavy metals in the plastics waste stream are in particulate form, tightly bonded to waste recording tape and are, therefore, not considered hazardous. The other waste streams and the process waste categories not present in a sufficient number of plants to quantify (concentrated cyanides, concentrated acids and alkalies and scrap metal) also contain heavy metals. Heavy metals in the scrap metal category would not be sufficiently soluble to be hazardous. However, heavy metals in concentrated cyanides and concentrated acids and alkalies are already in solution and are, therefore, hazardous.

- Fluorides are present in high concentrations only in the process waste waters and wastewater treatment sludges of plants which clean or etch glass or silicon (SIC's 3671, 3672 and 3674 primarily). Present development documents for effluent guidelines applicable to the electronic components manufacturing industry [7,8,9] are not specific as to the need to remove fluorides, but the toxic properties of fluorides at high concentrations are recognized. Removal of fluorides along with heavy metals by coprecipitation at elevated pH, plus possible future requirements to remove fluorides, even if present independently of heavy metals, contribute to the presence of fluorides in the wastewater treatment sludges.

- Oils are most abundant in the lubricating and hydraulic oils waste stream. The sensitivity of many aquatic species to non-vegetable oils, plus the presence in many industrial oils of a great variety of toxic additives, are the basis for classifying oils as hazardous constituents.

The processes in surveyed plants which generated the various process wastes are identified and described in Section III of this report. Table III-10 correlates the processes with the types of land-disposed waste generated by each.

Three of the five potentially hazardous waste streams each originate from a limited number of manufacturing process categories. Paint wastes are generated solely by operations in the materials coating process category. Halogenated solvent wastes, with a few minor exceptions, are generated by solvent cleaning and drying. The hydraulic and lubricating oil wastes are generated generally within two process categories: mechanical material removal (lubricating oils) and, to a lesser extent, metal forming (lubricating and hydraulic oils). Small amounts of hydraulic oil are also wasted from machinery used in other process categories such as plastics molding and non-plastics molding.

Wastewater treatment sludges and non-halogenated solvents, however, are each wasted from a number of process categories. Many of the processes included in the mechanical material removal, material forming, material coating and, especially, chemical-electrochemical process categories require water either in the process itself or to transport process wastes. Any onsite treatment of the wastewaters yields residues which typically must be land disposed. Process waste material contributions to any one plant's wastewater treatment sludge usually come from several processes simultaneously, thereby precluding the possibility of economic recovery of materials in the sludge.

Similarly, non-halogenated solvent wastes are frequently generated by processes in several process categories: mechanical material removal, material forming and material coating process categories in addition to solvent cleaning and drying processes. Segregation of non-halogenated solvent wastes generated within any one plant is more feasible than segregation of water carried wastes. Economic recovery of some solvent wastes, even when segregated, would be difficult to achieve because of relatively low costs for fresh solvents and high levels of contamination in many waste solvents.

Treatment and Disposal Technology

On-site treatment is common for the halogenated solvents and wastewater treatment sludge waste streams. Treatment of halogenated solvent wastes involves reclamation by distillation either in the holding tank used for cleaning or, in plants using large solvent quantities, in separate, centrally located units. Solvents treated on-site are reused in operations which do not have stringent quality control requirements.

Wastewater treatment sludges are typically concentrated either by lagooning or by physical means such as centrifugation or filter pressing. Because of the large number of constituents in wastewater treatment sludges, recovery and reuse of the sludge constituents is not practiced and is not practicable on-site.

Some in-process treatment of materials used in production, such as filtering of plating baths and settling of water soluble cutting oils, is practiced. Since these methods do not treat wastes, but produce them instead, they are not considered here to be on-site waste treatment processes, although the distinction in some cases is very fine.

Off-site treatment of halogenated solvent and non-halogenated solvent wastes is common. Treatment is directed toward reclamation and ranges from repackaging of slightly contaminated solvents to multiple fractionation procedures for mixed still bottoms. Some incineration of solvent wastes, both on- and off-site, was recognized during plant and contractor visits. Whereas halogenated solvents were found to be reclaimed both on- and off-site, non-halogenated solvents were not commonly reclaimed on-site, presumably because of the fire hazards involved in their distillation and recovery.

Reclamation of oil wastes is limited to petroleum distillates which are generated in large volumes. No treatment of water soluble cutting oils, the most common process waste in this category, was recognized.

No treatment of plastic wastes was noted. Thermoplastic scrub material is usually recycled through the molding process, but the use of these plastics was limited in the surveyed plants. Wasted plastics are stored and hauled directly to landfills.

On-site disposal of potentially hazardous waste streams was practiced in surveyed plants for thirteen percent of the wastes, by annual wet weight.

One large, terminal wastewater lagoon, and a large volume on-site surface dump operation account for most of this on-site disposal volume. The remainder of on-site disposal operations were surface dumps of small volume solvent wastes. The small number of examples found for on-site disposal does not form an adequate basis for extrapolating to estimates of on-site disposal by product area or by waste stream.

Off-site disposal of the potentially hazardous waste streams was generally by landfill either in separate drummed or undrummed liquid disposal areas, or in a mixture with municipal solid waste. Extensive use of landfills designed for receiving hazardous wastes and minimizing leachate and runoff contamination of water resources (secured landfills) was noted in the state of California. Secured landfill disposal of potentially hazardous wastes was also noted for at least one potentially hazardous process waste in each of three other states: Illinois, New York and Massachusetts.

All off-site treatment and disposal of wastes was performed by private contractors for the surveyed plants. Contractor services ranged from hauling wastes to municipally-owned landfills to complex, multiple waste stream reclamation, residue incineration and secured landfill operations. Most contractors provide only one service to the plant to which they are contracted. The use of multiple contractors for a plant is more common than a single contractor providing multiple services.

The U.S. Environmental Protection Agency has defined three levels of treatment and disposal technology which are or may be applicable to potentially hazardous waste streams generated by the industries which manufacture electronic components and are destined for land disposal. These technology levels are defined as follows:

LEVEL I - The technology currently employed by the majority of facilities -- i.e., broad average present treatment and disposal practice.

LEVEL II - The best technology currently employed. Identified technology at this level must represent the soundest process from an environmental and public health standpoint currently in use in at least one location. Installations must be commercial scale. Pilot and bench scale installations are not considered for this level.

LEVEL III - The technology necessary to provide adequate health and environmental protection. Level III technology may be more or less sophisticated or may be identical with Level I or Level II technology. At this level, identified technology may include pilot or bench scale processes providing the exact stage of development is identified.

Waste storage, reclamation, volume reduction and disposal methods under each technology level and for the five potentially hazardous waste streams of the electronic components manufacturing industry are summarized in Table I-6. Details of treatment and disposal technology for these waste streams are discussed in Section IV of this report. In general, the industry recognizes the

TABLE I-6

Summary of Treatment and Disposal Methods Provided for the Five Potentially Hazardous Waste Streams of the Electronic Components Manufacturing under the Three Technology Levels. Numerals indicate that the treatment or disposal method is incorporated in the contractors' definition of Level I, II or III technology for that waste stream.

| Potentially Hazardous Waste Streams | Storage | | Reclamation | | Volume Reduction | | Disposal | |
|---|---|---|---|---|---|---|---|---|
| | Unsegregated | Segregated | On-Site | Off-Site | Incineration | Dewatering | Off-site Landfill | Off-site Secured Landfill |
| Halogenated Solvents : | | I, II, III | I,II,III | I,II,III | | | I | II, III |
| Non-halogenated Solvents | | | | | | | | |
| Reclaimable : | | I, II, III | | I,II,III | | | I | II, III |
| Non-Reclaimable : | | I, II, III | | | III | | I | II, III |
| Wastewater Treatment Sludges : | | I, II, III | | | | II, III | I | II, III |
| Lubricating and Hydraulic Oils : | I | II, III | II, III | II, III | | | I, II | III |
| Paint Wastes : | I | II, III | | | II, III | | I, II | III |

Level I - Technology currently employed by the majority of facilities
Level II - Best technology currently employed
Level III - Technology necessary to provide adequate health and environmental protection.

value and/or hazards of the halogenated solvents, non-halogenated solvents and wastewater treatment sludge waste streams. More attention is paid to their proper treatment and disposal than the smaller, but still potentially hazardous, oil and paint waste streams.

## Costs of Treatment and Disposal

Estimated treatment and disposal costs for each potentially hazardous waste stream are shown in Table I-7. Based on 1975 waste generation rates, the total cost to the industry for Level I technology is $1,258,000/year. Level II technology applied to 1975 waste generation rates would increase costs by 34 percent to $1,683,000/year. Similarly, Level III technology would increase costs by 35 percent over Level I technology to $1,696,000. The cost increase between Level I and Level II technology results primarily from dewatering and secured landfilling of wastewater treatment sludges, and from secured landfilling of unreclaimable non-halogenated solvents. Additional cost increases between Level II and III are due to increased reclamation of lubricating and hydraulic oils, with secured landfilling of residual oil sludges, and to segregation and incineration of paint wastes, followed by ash disposal in a secured landfill. Since the oil and paint waste stream quantities are small compared to the other major waste streams, the overall cost increase to the industry for Level III above Level II is less than one percent.

The costs of potentially hazardous waste treatment and disposal for any of the three technology levels is expected to have insignificant impacts on the economic structure of the industry as a whole. The industry costs for treatment and disposal of potentially hazardous wastes as a percentage of industry profits, before taxes, is estimated for 1975 to be 0.2 percent for Level I, and 0.27 percent for Levels II and III.

Using Census data [10] for the number of electronic component manufacturing plants nationwide in 1975 and waste generation rates developed in this study, it is estimated that the average plant generates 22.2 kkg/yr of potentially hazardous wastes. The average plant's costs for treatment and disposal of these wastes increases from $501/yr for Level I to $673/yr for Level II and $678/yr for Level III. Table I-8 shows the costs attributable to each potentially hazardous waste stream.

## TABLE I-7

## ESTIMATED POTENTIALLY HAZARDOUS WASTE TREATMENT AND DISPOSAL COSTS

| PROCESS WASTE | $/kkg of Waste on Wet Weight Basis ($/ton) | | |
|---|---|---|---|
| | LEVEL I | LEVEL II | LEVEL III |
| Halogenated Solvents | | | |
| Reclamable (credit) | [51(46)][1] | [48(44)][1] | [47(44)][1] |
| Non-Reclamable | 55(50)[1] | 55(50)[1] | 55(50)[1] |
| Non Halogenated Solvents | | | |
| Reclamable (credit) | [40(36)][1] | [37(34)][1] | [37(34)][1] |
| Non-Reclamable | 55(50)[1] | 62(57)[2] | 62(57)[2] |
| Waste Treatment Sludge | 22(20)[3] | 33(30)[4] | 33(30)[4] |
| Lubricating and Hydraulic Oils | 22(20)[3] | 19(17)[3] | 27(24)[3] |
| Paint Wastes | 10(9)[3] | 51(46)[3] | 54(49)[3] |

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[1] Plant Data or Industry Data.

[2] Source: Reference [37].

[3] Source: Reference [33].

[4] Source: Reference [43].

## TABLE I-8

### TREATMENT AND DISPOSAL COSTS FOR POTENTIALLY HAZARDOUS WASTES AT AN AVERAGE ELECTRONIC COMPONENTS MANUFACTURING PLANT BY WASTE STREAM AND TREATMENT AND DISPOSAL TECHNOLOGY LEVEL[1]

| Potentially Hazardous Waste Stream | Waste Generation Rate per Plant (kkg/year) | | Plant Cost in $/year | | |
|---|---|---|---|---|---|
| | | | Level I | Level II | Level III |
| Halogenated Solvents[2] | 4.3 | | | | |
| reclaimable | | 2.58 | [132] | [124] | [124] |
| non-reclaimable | | 1.72 | 94.6 | 94.6 | 94.6 |
| Non-Halogenated Solvents[3] | 6.16 | | | | |
| reclaimable | | .62 | [24.6] | [22.8] | [22.8] |
| non-reclaimable | | 5.54 | 305 | 344 | 344 |
| Wastewater Treatment Sludges | 11.1 | | 244 | 366 | 366 |
| Lubricating and Hydraulic Oils | 0.6 | | 13.2 | 11.4 | 16.2 |
| Paint Wastes | 0.08 | | .8 | 4.1 | 4.3 |
| Totals | 22.24 | | 501.0 | 673.3 | 678.3 |

---

[1] Based on 2,500 plants in 1975 [10], 1975 waste stream generation rates from Table III-1, and unit costs from Table V-1.

[2] Assume 60% reclaimable; 40% non-reclaimable.

[3] Assume 10% reclaimable; 90% non-reclaimable.

# SECTION II

# DESCRIPTION OF THE ELECTRONIC COMPONENTS MANUFACTURING INDUSTRY

## INTRODUCTION

The products and economic structure of the Electronic Components Manufacturing Industry are described in this section. Employment, number of plants, and value of shipments data are presented for the nine product groups of the industry. The geographic distributions of plants and of production for each of the nine product areas is also presented. Production, as measured by value of plant shipments, is used later in this report to extrapolate waste volumes from plant visit data for the industry. Economic trends in the electronic components manufacturing industry in terms of increase in value of shipments are analyzed.

The three-digit Standard Industrial Classification (SIC) for this industry is 367. This U.S. Department of Commerce classification has been used to define the scope of this study in terms of the types of industrial plants to be studied.

The following sources of information were used in developing the following industry characterization: the 1972 Census of Manufactures for Communication Equipment, including Radio and TV, and Electronic Components and Accessories [5], the Dun and Bradstreet Marketing Services for Manufacturers, 1975 [6], and U.S. Industrial Outlook, 1976 [10]. The 1972 Census of Manufactures has been used as the prime source of statistical information about the industry. In instances where the Census of Manufactures data are insufficient, data extracted from Dun and Bradstreet has been used as the basis for estimates. Analysis of economic trends in the industry depend largely upon government projections reported in U.S. Industrial Outlook 1976.

## PRODUCTS OF THE INDUSTRIES

SIC 367 products are components intended for use in the assembly of electronic end products and equipment. This SIC is defined by product function, not by materials or processes used in their manufacture. This, plus advances in electronics research that constantly creates new manufacturing processes and new products, result in complex, rapidly evolving market and manufacturing structures within the industry.

The 1972 Census of Manufactures provides detailed listings of the products of SIC 367. There are nine general categories of products in the industry as defined by the four-digit SIC - 3671 through 3679 as listed below:

| SIC | Product Category |
|---|---|
| 3671 | Electron Tubes, Receiving Type |
| 3672 | Cathode Ray TV Picture Tubes |

| SIC | Product Category |
|---|---|
| 3673 | Electron Tubes, Transmitting and Special Purpose |
| 3674 | Semi conductor and Related Devices |
| 3675 | *Capacitors for Electronic Applications |
| 3676 | *Resistors for Electronic Applications |
| 3677 | *Electronic Coils and Transformers and other Inductors |
| 3678 | *Connectors for Electronic Applications |
| 3679 | Electronic Components, Not Elsewhere Classified |

* - Plants with primary products in these product categories were given four-digit classifications for the first time in the 1972 Census of Manufactures. Prior to that they were included in SIC 3679 - Electronic Components, not elsewhere classified.

Products are further sub-categorized into seven-digit SICs. A list of these SIC categories is presented in Appendix A.

It is important to note that SIC 3679 is a grouping of numerous types of electronic components which have little in common except the fact that they individually do not merit ranking as four-digit SIC. Whereas there is some degree of product and manufacturing similarity within each of the other eight four-digit SIC's, SIC 3679 encompasses the miscellany of the industry. Nevertheless, on the basis of total value of product shipments, SIC 3679 plants represents 34.6 percent of the electronic components manufacturing industry.

## ECONOMIC STRUCTURE

The overall size of the electronic components industry is reflected in the following figures taken from the 1972 Census of Manufactures [5].

| | |
|---|---|
| Total number of establishments | 2,855 |
| Total number of employees | 334,500 |
| Total value of shipments, including interplant transfers | $8,561,000,000 |

Similar statistics are presented in Table II-1 for each four-digit SIC. The percentage of industry establishments, employees and value of shipments in each four-digit SIC are also shown. On the basis of all these parameters, the largest segments of the industry are SIC 3679, Electronic Components-Not Elsewhere Classified and SIC 3674, Semiconductors and Related Devices. While SIC 3674 includes a relatively small number of products which are closely related in terms of manufacturing processes and product function, SIC 3679 has tremendous product and manufacturing process variety as discussed below.

TABLE II-1

Economic Data for the Four-digit SIC categories in the Electronic Components Manufacturing Industry

| | | Number of Establishments | | Number of Employees | | Number of Production Workers | | Value of Shipments $ million | |
|---|---|---|---|---|---|---|---|---|---|
| | | # | % | # | % | # | % | # | % |
| 3671 | Electron tubes, receiving type | 25 | .9% | 11,400 | 3.4% | 9,500 | 4.1% | 230.4 | 3.6% |
| 3672 | Cathode-ray television picture tubes | 75 | 2.6% | 15,000 | 4.5% | 12,200 | 5.3% | 696.5 | 7.9% |
| 3673 | Electron tubes, transmitting | 53 | 1.8% | 20,500 | 6.1% | 12,300 | 5.3% | 479.3 | 5.5% |
| 3674 | Semiconductors & related devices | 325 | 11.4% | 97,000 | 29.0% | 58,100 | 25.0% | 2,686.9 | 30.5% |
| 3675 | Electronic capacitors | 113 | 4.0% | 27,700 | 8.3% | 22,500 | 9.7% | 445.8 | 5.1% |
| 3676 | Electronic resistors | 86 | 3.0% | 20,500 | 6.1% | 15,700 | 6.8% | 372.2 | 4.2% |
| 3677 | Electronic coils and and transformers | 246 | 8.6% | 23,600 | 7.1% | 19,100 | 8.2% | 353.5 | 4.0% |
| 3678 | Electronic connectors | 92 | 3.2% | 18,500 | 5.5% | 12,800 | 5.5% | 491.9 | 5.6% |
| 3679 | Electronic components, not elsewhere classified | 1,840 | 64.5% | 100,700 | 30.0% | 69,000 | 30.1% | 3,041.6 | 34.6% |
| | TOTAL | 2,855 | 100.0% | 334,900 | 100.0% | 232,100 | 100.0% | 8,798.1 | 100.0% |

SOURCE: 1972 Census of Manufactures

As an index to the production levels for the diverse products in SIC 3679, the 1972 total value of shipments for major product categories (as grouped in the 1972 Census of Manufactures) within the SIC are presented in Table II-2. It is noteworthy that the largest subcategory within SIC 3679 again is the "not elsewhere classified" sub-category. This subcategory, for which no product descriptions are given, represents 18 percent of the entire electronic components industry on the basis of value of shipments. The percentage of plants manufacturing items in this miscellaneous subcategory is likely higher than 18 percent since SIC 3679 plants have a lower average value of shipments than the rest of the industry ($1.6 million per year per plant for SIC 3679 vs $5.6 million per year per plant for the other eight four-digit SICs). An estimated 34 percent of the plants in the electronic components industry produce as primary products components which are not specified by kind at either the four-or seven-digit levels in the Census of Manufactures.

Manufacturing plants are assigned to an SIC based upon the shipment values of products. The product within a plant having the highest shipment value is the primary product of that plant. Secondary products and receipts for activities such as merchandising and contract work also contribute to the plant's total value of shipments. The value of primary products shipped by all of the plants classified within an SIC as a percentage of the value of both primary and secondary products shipped is the "primary product specialization ratio" for the industry. The ratio of value of primary product shipments for an SIC to the total value of shipments for the SIC product, regardless of what type of plant it was made in, is the "coverage ratio" for the product. Both of these ratios are indices to the product mix for plants in an SIC. The primary product specialization ratios and the coverage ratios for the four-digit SICs of the electronic components manufacturing industry are presented in Table II-3. As an example, plants primarily making resistors, SIC 3676, also produce other products which contribute 10 percent of their value of industry shipments. Resistors account for 90 percent of their shipments, (primary product specialization ratio). However, only 74 percent of all resistors made in this country are manufactured by SIC 3676 plants (coverage ratio).

This product mix information indicates that there is some degree of integration within SIC 367 plants. That is, some plants produce secondary products. These secondary products may or may not be electronic components. Few of the plants visited for this study had products in only one four-digit SIC. In general, smaller plants appear to be less integrated than high product volume plants.

## GEOGRAPHIC DISTRIBUTION OF PLANTS

Table II-4 indicates how the 2,855 electronic components manufacturing plants reported in the 1972 Census of Manufactures are distributed in the United States. Breakdowns for each four-digit SIC are given by State, EPA Region and nationally. In most instances, the Commerce Department cannot re-

## TABLE II-2

## Total Value of Shipments for Product Groups in SIC 3679

| | Table Value of Shipments including Interplant Transfers ($ million) | % of Total |
|---|---|---|
| Electronic parts not elsewhere classified, specialized electronic hardware and parts not specified by kind | 1583.6 | 55.5 |
| Magnetic recording media | 254.4 | 8.9 |
| Printed circuit boards | 184.9 | 6.5 |
| Antennas and accessories | 111.9 | 3.9 |
| Microwave components and subassemblies | 103.3 | 3.6 |
| Electron tube parts | 98.3 | 3.5 |
| Static power supply converters | 98.1 | 3.5 |
| Crystals, filters and related devices | 95.3 | 3.3 |
| Switches, mechanical types for electronic circuitry | 77.9 | 2.7 |
| Transducers | 62.9 | 2.2 |
| Relays | 40.6 | 1.4 |
| Phonographic cartridges and pickups | 38.7 | 1.4 |
| Phonographic needles and cutting stylii | 33.0 | 1.2 |
| Earphones and headsets | 26.0 | .9 |
| Complex components (two or more components packaged and shipped as a single unit) | 22.8 | .8 |
| Delay lines | 19.1 | .7 |
| | 2850.8* | 100.0 |

* - This value is not the same as that given for SIC 3679 in Table II-1. The original source of the above information was the Current Industrial Reports series MA-36N as reported in the 1972 Census of Manufactures. The information in Table II-1 has a different data base and can not be disaggregated to individual product groups.

## TABLE II-3

## Product Mix in the Electronic Components Industry as shown by Primary Product Specialization Ratio and Coverage Ratio

| SIC | Primary Product Specialization Ratio % | Coverage Ratio % |
|---|---|---|
| 3671 Electron tubes, receiving | 83 | 94 |
| 3672 TV tubes | 91 | 98 |
| 3673 Electron tubes, transmitting | 68 | 92 |
| 3674 Semiconductors | 89 | 92 |
| 3675 Capacitors | 90 | 87 |
| 3676 Resistors | 90 | 74 |
| 3677 Coils and Transformers | 87 | 79 |
| 3678 Connectors | 87 | 81 |
| 3679 Miscellaneous | 72 | 80 |

$$\text{Primary Product Specialization Ratio} = \frac{\text{Value of Primary Product Shipments}}{\text{Value of Primary and Secondary Product Shipments for plants with the primary SIC}}$$

$$\text{Coverage Ratio} = \frac{\text{Value of Primary Product Shipments}}{\text{Value of Primary Product Shipments in all Industries}}$$

Source: 1972 Census of Manufactures

TABLE II-4

SIC 367 Electronic Components Manufacturing Industry - Geographic Distribution of Plants

| State | EPA Region | SIC 3671 Electron Tube, Receiving Type | SIC 3672 Cathode Ray - TV Picture Tubes | SIC 3673 Electron Tubes Transmitting | SIC 3674 Semiconductors and Related Devices | SIC 3675 Electronic Capacitors | SIC 3676 Electronic Resistors | SIC 3677 Electronic Coils and Transformers | SIC 3678 Electronic Connectors | SIC 3679 Electronic Components N. E. C. | State Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. AL | IV | | | | 1 | 1 | | | 1 W | 18 W | 21 |
| 2. AK | X | | | | | | | | | | 0 |
| 3. AZ | IX | | | | 8 | 2 | 1 W | 1 | | 28 W | 40 |
| 4. AR | VI | 4 W | 1 | | | | | 2 | 1 | 3 | 11 |
| 5. CA | IX | 1 W | 5 W | 12 | 110 W | 20 | 14 | 36 | 22 | 432 | 652 |
| 6. CO | VIII | | 1 W | | | | 2 | 1 W | 1 | 26 W | 29 |
| 7. CT | I | | 1 W | 3 | 9 | 6 | 3 | 7 | 6 | 64 | 99 |
| 8. DE | III | | | | | | | | | | 0 |
| 9. DC | III | | 1 W | | | | | | | 2 | 3 |
| 10. FL | IV | | 4 W | 3 | 10 W | 2 | 4 W | 10 | 2 | 59 W | 94 |
| 11. GA | IV | | 1 W | 1 | 1 W | | | 1 W | | 1 W | 5 |
| 12. HI | IX | | | | | | | | | | 0 |
| 13. ID | X | | | | 2 | | | | | 1 W | 3 |
| 14. IL | V | 2 W | 8 | 2 | 6 W | 10 W | 6 | 53 | 8 | 130 | 225 |
| 15. IN | V | 1 | 5 | | 1 W | 5 | 7 | 14 | 3 | 30 | 66 |
| 16. IA | VII | | 1 W | | 1 W | | 3 | 4 | | 7 W | 16 |
| 17. KS | VII | | | | 1 W | | | 1 W | 1 | 15 | 18 |
| 18. KY | IV | 1 W | | 1 W | | 1 | | | | 7 W | 10 |
| 19. LA | VI | 1 | | | | | | | | | 1 |
| 20. ME | I | | 1 W | | 2 | 2 | | 1 W | | 3 | 9 |
| 21. MD | III | | 2 W | 1 W | 2 W | | | | | 30 W | 35 |
| 22. MA | I | 2 W | | 10 | 35 W | 4 | 5 | 8 W | 6 | 140 | 210 |
| 23. MI | V | | 1 W | 1 W | 5 | | | 8 | 1 | 35 | 51 |
| 24. MN | V | | 1 W | | 2 W | | | 6 | 2 | 39 | 50 |
| 25. MS | IV | | | | | 3 | | | | 1 W | 4 |
| 26. MO | VII | | | | 3 | | | 4 W | 1 W | 19 | 27 |
| 27. MT | VIII | | | | | | | | | | 0 |
| 28. NE | VII | | 1 W | | | 2 | 2 W | 1 W | 1 W | 6 | 13 |
| 29. NV | IX | | 1 W | | | | | | | 1 W | 2 |
| 30. NH | I | | 1 W | 1 | 1 W | 3 | 4 | 1 W | 1 | 15 | 27 |
| 31. NJ | II | 3 | 5 | 7 | 30 | 10 | 9 | 17 | 3 | 165 | 249 |
| 32. NM | VI | | | 1 W | 1 | | | | | 2 W | 4 |
| 33. NY | II | 2 W | 10 | 3 | 38 | 9 | 4 | 32 | 11 | 230 | 339 |
| 34. NC | IV | | | | 2 W | 3 | 6 W | | | 13 W | 24 |
| 35. ND | VIII | | | | | | | | | | 0 |
| 36. OH | V | 1 | 8 | | 9 W | 1 | 1 W | 10 | 4 | 59 | 93 |
| 37. OK | VI | | | | | | | | 1 W | 21 | 22 |
| 38. OR | X | | 1 W | | | | | 2 | | 10 | 13 |
| 39. PA | III | 7 | 5 | 4 | 19 | 8 | 10 | 9 | 9 | 85 | 156 |
| 40. RI | I | | | | 4 | | 1 W | | 3 | 11 | 19 |
| 41. SC | IV | | | | | 5 | | 1 | | | 6 |
| 42. SD | VIII | | | | | | | 2 | | 2 | 4 |
| 43. TN | IV | | | | | 3 | | 3 | | 3 W | 9 |
| 44. TX | VI | 1 W | 5 W | | 14 | 3 | 2 | 4 | 2 W | 63 | 94 |
| 45. UT | VIII | | | 2 | 2 | | | | | 3 W | 7 |
| 46. VT | I | | | | 1 | 2 | | | | | 3 |
| 47. VA | III | | 1 W | 1 | 5 | 5 | 1 | | 1 W | 19 W | 33 |
| 48. WA | X | | 1 W | | | | | | 1 W | 15 | 17 |
| 49. WV | III | | 1 W | | | | 1 | 1 | | | 3 |
| 50. WI | V | | 1 W | | | 3 | | 6 | | 29 | 39 |
| 51. WY | VIII | | | | | | | | | | 0 |
| National Totals | | 25 | 75 | 53 | 325 | 113 | 86 | 246 | 92 | 1840 | 2855 |
| EPA Region | I | 2 | 3 | 14 | 52 | 17 | 13 | 17 | 16 | 233 | 367 |
| | II | 5 | 15 | 10 | 68 | 19 | 13 | 49 | 14 | 395 | 588 |
| | III | 7 | 10 | 6 | 26 | 13 | 12 | 10 | 10 | 136 | 230 |
| | IV | 1 | 5 | 5 | 14 | 18 | 10 | 15 | 3 | 102 | 173 |
| | V | 4 | 26 | 3 | 23 | 19 | 14 | 97 | 18 | 322 | 526 |
| | VI | 5 | 7 | 1 | 15 | 3 | 2 | 6 | 4 | 89 | 132 |
| | VII | 0 | 2 | 0 | 5 | 2 | 5 | 12 | 3 | 49 | 78 |
| | VIII | 0 | 1 | 2 | 2 | 0 | 2 | 1 | 1 | 27 | 36 |
| | IX | 1 | 6 | 12 | 118 | 22 | 15 | 37 | 22 | 461 | 694 |
| | X | 0 | 2 | 0 | 2 | 0 | 0 | 2 | 1 | 26 | 33 |

Source: 1972 Census of Manufactures supplemented by WAPORA estimates indicated by "W". Most state plant totals and all EPA Region Plant Totals include some numbers estimated by WAPORA.

port the number of plants in a state if doing so would result in disclosing production information for individual companies. Therefore, where number of plants given for any state in Table II-4 is three or less, the number is usually a WAPORA estimate. (Total numbers of plants for individual states and for EPA regions will be in error according to the number of states for which estimates had to be made).

According to all sources of information used in developing Table II-4, four states - Alaska, Montana, North Dakota, and Wyoming - have no electronic component manufacturing plants. California has 22 percent or 652 of the SIC 367 plants in the nation. Five other states have over 100 plants: New York (339), New Jersey (249), Illinois (225), Massachusetts (210), and Pennsylvania (156). These six states with the greatest number of plants have 64 percent of the electronic component manufacturing plants in the nation and are all heavily industrialized with other types of plants. The four EPA regions in which these states are located, Regions I, II, V and IX, collectively have 76 percent of the electronic component manufacturing plants. Figure II-1, illustrates the national distribution of SIC 367 plants.

The reason or reasons for concentration of this industry in the northeast states, Great Lakes states and California are not explicitly stated in available information sources. Availability of skilled labor and proximity to distribution sources for specialized chemicals and materials are probable causes for the demonstrated geographical concentration of the industry.

## EMPLOYMENT

The number of total employees and of production workers in the plants within each primary four-digit SIC has been reported in Table II-1. The 1972 Census of Manufactures disaggregates the number of total employees in each SIC according to the number of employees per plant. The number of plants in several employment size ranges are presented for each four-digit SIC in Table II-5 as extracted from the Census data.

Disaggregation by state and EPA Region of the numbers presented in Table II-5 was attempted using the Dun and Bradstreet Marketing Services for Manufactures, 1975 [6]. Many of the entries in the Dun and Bradstreet listing include the number of employees at a plant. Tabulation of the numbers is presented in Table II-6.

In all categories where Census and Dun and Bradstreet data are comparable, i.e., national and state totals, SIC 3671, SIC 3672 and SIC 3673, the numbers derived from Dun and Bradstreet are higher. Some of this difference may be due to growth of the industry between 1972 and 1975. However, this large apparent increase in the number of plants is not supported by the facts [5] that (1) the industry-wide increase in the number of plants between the 1967 and 1972 Census was only 15 percent; and (2) the number of plants for SICs 3671, 3672, 3673, 3675 and 3676 actually decreased between 1967 and 1972. Such a dramatic change in plant numbers after 1972 as suggested by the Dun and Bradstreet data, therefore, does not seem likely. The high Dun and Bradstreet figures are attributed to some difference in criteria for including plants in the listing.

# TABLE II-5

## Employment Size of Establishments

| SIC | Establishments with an average of: | | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|
| | 0-9 employees | 10-19 employees | 20-49 employees | 50-99 employees | 100-499 employees | 500-999 employees | 1000+ employees | |
| 3671<br>Electron tubes, receiving | 9 | 3 | 1 | 2 | 3 | 4 | 3 | 25 |
| 3672<br>TV picture tubes | 48 | 6 | 4 | 5 | 4 | 2 | 6 | 75 |
| 3673<br>Electron tubes, transmitters | 11 | 4 | 5 | 8 | 13 | 7 | 5 | 53 |
| 3674<br>Semiconductors | 99 | 30 | 52 | 44 | 65 | 17 | 18 | 325 |
| 3675<br>Capacitors | 6 | 6 | 16 | 22 | 43 | 17 | 3 | 113 |
| 3676<br>Resistors | 3 | 5 | 13 | 16 | 39 | 8 | 2 | 86 |
| 3677<br>Coils and transformers | 17 | 25 | 74 | 55 | 71 | 3 | 1 | 246 |
| 3678<br>Connectors | 5 | 7 | 22 | 16 | 34 | 5 | 3 | 92 |
| 3679<br>Not elsewhere classified | 907 | 235 | 316 | 166 | 188 | 17 | 11 | 1842 |
| Total | 1105 | 321 | 503 | 334 | 460 | 80 | 52 | 2855 |

Source: 1972 Census of Manufactures

TABLE II-6

SIC 367 ELECTRONIC COMPONENTS MANUFACTURING — DISTRIBUTION OF PLANT SIZE
BY EMPLOYMENT, STATE, AND EPA REGION

| | SIC 3671 | | | | | | | | SIC 3672 | | | | | | | | SIC 3673 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-9 | 10-19 | 20-49 | 50-99 | 100-499 | 500-999 | 1000+ | Not shown | 0-9 | 10-19 | 20-49 | 50-99 | 100-499 | 500-999 | 1000+ | Not shown | 0-9 | 10-19 | 20-49 | 50-99 | 100-499 | 500-999 | 1000+ | Not shown |
| 1. AL | | | | | | | | | 2 | | | | | | | | | | | | | | | |
| 2. AK | | | | | | | | | | | | | | | | | | | | | | | | |
| 3. AZ | 1 | | | | | | | | | | | | | | | | | | 1 | | 1 | | | |
| 4. AR | 2 | 1 | | 2 | 3 | | | | 1 | | | | | | | | | | | | | | | |
| 5. CA | 1 | | 1 | | | 1 | | | 8 | 2 | | 1 | | | 1 | 1 | 6 | 4 | 4 | | | 3 | 1 | |
| 6. CO | 1 | | | | | | | | 1 | | | | | | | | 1 | | | | | | | |
| 7. CT | | | | 1 | | | | | 1 | | | | | | | | 1 | | 1 | | | | | |
| 8. DE | | | | | | | | | | | | | | | | | | | | | | | | |
| 9. DC | | | | | | | | | | | | | | | | | | | | | | | | |
| 10. FL | | 1 | | | | | | | 3 | 1 | | | | | | | | 1 | 1 | | 1 | | | |
| 11. GA | | | | | | | | | | | 1 | | | | | | | | | | | 1 | | |
| 12. HI | | | | | | | | | | | | | | | | | | | | | | | | |
| 13. ID | | | | | | | | | | | | | | | | | | | | | | | | |
| 14. IL | 4 | | | | 1 | | | | 1 | | 1 | | | 1 | | 2 | 1 | | | 2 | 1 | | | 1 |
| 15. IN | 1 | | | | | 1 | | | 1 | | 1 | | | 1 | | | | | | | | 1 | 1 | 1 |
| 16. IA | 1 | | | | | | | | 1 | | | | | | | | | | | | | | | |
| 17. KS | | | | | | | | | | | | | | | | | | | | | | | | |
| 18. KY | 1 | | | | | | 1 | | | | | | | | | | 1 | | | | | | | |
| 19. LA | | | | | | | | | | 1 | | | | | | | | | | | | | | |
| 20. ME | | | | | | | | | | | | | | | | | | | | | | | | |
| 21. MD | | | | | | | | | | | 1 | | | | | | | 1 | | | | | | |
| 22. MA | | | | | 1 | | | | | | 1 | | | | | | 4 | 1 | 2 | 2 | 3 | 2 | 1 | |
| 23. MI | | | | | | | | | | 1 | | | | 1 | | | 1 | | | | | | | |
| 24. MN | | | | | | | | | 2 | | 1 | | | | | | | | | | | | | |
| 25. MS | | | | | | | | | | | | | | | | | | | | | | | | |
| 26. MO | | | | | | | | | | | | | | | | | | | | | | | | |
| 27. MT | | | | | | | | | | | | | | | | | | | | | | | | |
| 28. NE | | | | | | | | | | | | | | | | | | | | | | | | |
| 29. NV | | | | | | | | | 1 | | | | | | | | | | | | | | | |
| 30. NH | | | | | | | | | | 1 | | | | | | | | | | | | | | |
| 31. NJ | | | 3 | 1 | 1 | 1 | | | 3 | | | 2 | 1 | | 1 | | 1 | | 3 | 1 | 1 | | 1 | 2 |
| 32. NM | | | | | | | | | | | | | | | | | | | | | | | | |
| 33. NY | 1 | | | 1 | | 1 | | | 5 | 1 | 1 | | | | 1 | 3 | 2 | 3 | 1 | 1 | | 2 | 1 | |
| 34. NC | | | | 1 | | | | | | | | | | | | | | | | | | | | |
| 35. ND | | | | | | | | | | | | | | | | | | | | | | | | |
| 36. OH | 1 | | | | 1 | | | | 2 | 1 | 1 | | | | 1 | | 1 | | 3 | 1 | 1 | | 1 | 2 |
| 37. OK | | | | | | | | | 2 | | | | | | | | | | | | | | | |
| 38. OR | | | | | | | | | 1 | | | | | | | | | | | | | | | |
| 39. PA | | 1 | | | 4 | 1 | 2 | | 1 | | 1 | | 3 | | 1 | | | | 1 | | | | | |
| 40. RI | | | | | | | | | | | | | | | | | | | | | | | | |
| 41. SC | | | | | 1 | | | | | | | | | | | | | | | | | | | |
| 42. SD | | | | | | | | | | | | | | | | | | | | | | | | |
| 43. TN | | | | | | | | | | | | | | | | | | | | | | | | |
| 44. TX | 1 | | | | 1 | | | | 3 | 2 | | | | | | | | | | | | | | |
| 45. UT | | | | | | | | | | | | | | | | | | | | | 1 | | | |
| 46. VT | | | | | | | | | | | | | | | | | | | | | | | | |
| 47. VA | | | | | 1 | | | | | | | | | | | | | | | | | | | |
| 48. WA | | | | | | | | | 3 | | | | | | | | | | | | | | | |
| 49. WV | | | | | | | | | 1 | | | | | | | | | | | | | | | |
| 50. WI | 1 | | | | | | | | 2 | | | | | | | | | | | | | | | |
| 51. WY | | | | | | | | | | | | | | | | | | | | | | | | |
| | 16 | 3 | 4 | 6 | 14 | 5 | 3 | | 45 | 10 | 9 | 3 | 4 | 3 | 5 | 6 | 18 | 11 | 14 | 6 | 10 | 10 | 5 | 3 |
| Dun & Bradstreet Total | | | | | | 51 | | | | | | | | 85 | | | | | | | | 77 | | |
| Census Total | | | | | | 75 | | | | | | | | 75 | | | | | | | | 53 | | |
| Region I | | | | 1 | 1 | | | | 1 | 1 | 1 | | | | | | 5 | 1 | 3 | 3 | 6 | 8 | 1 | |
| II | 1 | | 3 | 2 | 1 | 2 | | | 7 | 1 | 1 | 2 | 1 | | 2 | 3 | 3 | 3 | 4 | 2 | 1 | 2 | 2 | 2 |
| III | | 1 | | | 5 | 1 | 2 | | 2 | | 2 | | 3 | | 1 | | | 1 | 1 | | | | | |
| IV | 1 | 1 | | 1 | 1 | | 1 | | 6 | 1 | 1 | | | | | | 1 | 1 | 1 | | 1 | 1 | | |
| V | 7 | | | | 2 | 1 | | | 8 | 2 | 4 | | | 3 | 1 | 2 | 2 | 1 | | 3 | 2 | 2 | 1 | 1 |
| VI | 3 | 1 | | 2 | 4 | | | | 6 | 3 | | | | | | | | | | | | | | |
| VII | 1 | | | | | | | | 1 | | | | | | | | | | | | | | | |
| VIII | 1 | | | | | | | | 1 | | | | | | | | 1 | | | | 1 | | | |
| IX | 2 | | 1 | | | 1 | | | 9 | 2 | | 1 | | | 1 | 1 | 6 | 4 | 5 | | 1 | 3 | 1 | |
| X | | | | | | | | | 4 | | | | | | | | | | | | | | | |
| National | 16 | 3 | 4 | 6 | 14 | 5 | 3 | | 45 | 10 | 9 | 3 | 4 | 3 | 5 | 6 | 18 | 11 | 14 | 6 | 10 | 10 | 5 | 3 |

## TABLE II-6
## (Continued)

| | SIC 3674 | | | | | | | | SIC 3675 | | | | | | | SIC 3676 | SIC 3677 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-9 | 10-19 | 20-49 | 50-99 | 100-499 | 500-999 | 1000+ | Not shown | 0-9 | 10-19 | 20-49 | 50-99 | 100-499 | 500-999 | 1000+ | 50-99 | 0-9 | 10-19 | 20-49 | 50-99 | 100-499 | 500-999 |
| 1. AL | | | | | | 1 | | | | | | | | | | | | | | | | |
| 2. AK | | | | | | | | | | | | | | | | | | | | | | |
| 3. AZ | | | | | | | | | | | | | | | | | | | | | | |
| 4. AR | | | | | | | | | | | | | | | | | | | | | | |
| 5. CA | | 2 | 4 | 1 | 1 | 1 | 1 | 2 | | | | | | | | | | | | | | |
| 6. CO | | | | | | | | | | | | | | | | | 2 | | | | | |
| 7. CT | 1 | 1 | | | | | | | | | | | | | | | | | | | | |
| 8. DE | | | | | | | | | | | | | | | | | | | | | | |
| 9. DC | | | | | | | | | | | | | | | | | | | | | | |
| 10. FL | | | 1 | | | | | | | | | | | | | | | | | | | |
| 11. GA | | | | | | | | | | | | | | | | | | | | | | |
| 12. HI | | | | | | | | | | | | | | | | | | | | | | |
| 13. ID | | | | | | | | | | | | | | | | | | | | | | |
| 14. IL | | | | | | | | | | | | | | | | | | | | | | |
| 15. IN | | | | | | | | | | | | | | | | 1 | | | | | 2 | 1 |
| 16. IA | | | | | | | | | | | | | | | | | | | | | | |
| 17. KS | | | | | | | | | | | | | | | | | | | | | | |
| 18. KY | | | | | | | | | | | | | | | | | | | | | | |
| 19. LA | | | | | | | | | | | | | | | | | | | | | | |
| 20. ME | | | | | | | | | | | | | | | | | | | | | | |
| 21. MD | | | | | | | | | | | | | | | | | | | | | | |
| 22. MA | 1 | | 1 | 2 | 2 | 1 | 1 | | | | | | | | 1 | | | | | | | |
| 23. MI | | | | | | | | | | | | | | | | | | | | | | |
| 24. MN | | | | | | | | | | | | | | | | | | | | | | |
| 25. MS | | | | | | | | | | | | | | | | | | | | | | |
| 26. MO | | | | | | | | | | | | | | | | | | | | | | |
| 27. MT | | | | | | | | | | | | | | | | | | | | | | |
| 28. NE | | | | | | | | | | | | | | | | | | | | | | |
| 29. NV | | | | | | | | | | | | | | | | | | | | | | |
| 30. NH | | | | | 1 | | | | | | | | | | | | | | | | | |
| 31. NJ | | | | | | | | | | | | | | | | | | | | | | |
| 32. NM | | | | | | | | | | | | | | | | | | | | | | |
| 33. NY | 1 | | 2 | | 2 | | | 2 | | | | | 1 | | | | | | | 1 | 1 | |
| 34. NC | | | | | | | | | | | | | | | | | | | | | | |
| 35. ND | | | | | | | | | | | | | | | | | | | | | | |
| 36. OH | | | 1 | | | | | | | | | | | | | | | | | | | |
| 37. OK | | | | | | | | | | | | | | | | | 1 | | | | | |
| 38. OR | | | | | | | | | | | | | | | | | | | | | | |
| 39. PA | | | | | | | | | | | | | | | | | | | | | | |
| 40. RI | 1 | | | | | | | | | | | | | | | | | | | | | |
| 41. SC | | | | | | | | | | | | | | | | | | | | | | |
| 42. SD | | | | | | | | | | | | | | | | | | | | | | |
| 43. TN | | | | | | | | | | | | | | | | | | | | | | |
| 44. TX | | | 1 | | 1 | | 1 | | | | | | | | | | | | | | | |
| 45. UT | 1 | | | | | | | | | | | | | | | | | | | | | |
| 46. VT | | | | | | | | | | | | | | | | | | | | | | |
| 47. VA | 1 | | | | | | | | | | | | | | | | | | | | | |
| 48. WA | | | | | | | | | | | | | | | | | | | | | | |
| 49. WV | | | | | | | | | | | | | | | | | | | | | | |
| 50. WI | | | | | | | | | | | | | | | | | | | | | | |
| 51. WY | | | | | | | | | | | | | | | | | | | | | | |
| | 6 | 3 | 10 | 3 | 12 | 3 | 3 | 4 | | | | | 1 | | 1 | 1 | 3 | | | 1 | 3 | 1 |
| Dun & Bradstreet Total | | | | | | | 44 | | | | | | | | 2 | 1 | | | | | | 8 |
| Census Total | | | | | | | 325 | | | | | | | | 113 | 86 | | | | | | 166 |
| Region I | 3 | 1 | 1 | 2 | 3 | 1 | 1 | | | | | | | | 1 | | | | | | | |
| II | 1 | | 2 | | 2 | | | 2 | | | | | 1 | | | | | | | 1 | 1 | |
| III | 1 | | | | | | | | | | | | | | | | | | | | | |
| IV | | | 1 | | | 1 | | | | | | | | | | | | | | | | |
| V | | | 1 | | | | | | | | | | | | | 1 | 1 | | | | 2 | 1 |
| VI | | | 1 | | 1 | | 1 | | | | | | | | | | | | | | | |
| VII | | | | | | | | | | | | | | | | | | | | | | |
| VIII | 1 | | | | | | | | | | | | | | | | | | | | | |
| IX | | 2 | 4 | 1 | 6 | 1 | 1 | 2 | | | | | | | | | 2 | | | | | |
| X | | | | | | | | | | | | | | | | | | | | | | |
| National | 6 | 3 | 10 | 3 | 12 | 3 | 3 | 4 | | | | | 1 | | 1 | 1 | 3 | | | 1 | 3 | 1 |

## TABLE II-6
(Continued)

| | SIC 3678 | | | | | | SIC 3679 | | | | | | | | D&B Total | Census Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20-49 | 50-99 | 100-499 | 500-999 | 1000+ | Not shown | 0-9 | 10-19 | 20-49 | 50-99 | 100-499 | 500-999 | 1000+ | Not shown | | |
| 1. AL | | | | | | | 2 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 18 | 21 |
| 2 AK | | | | | | | | | | | | | | | 0 | 0 |
| 3. AZ | | | | | | | 14 | 4 | 8 | 4 | 3 | | | 5 | 41 | 40 |
| 4. AR | | | | | | | | | | | | | | | 9 | 11 |
| 5. CA | 1 | | | | | 1 | 307 | 156 | 172 | 111 | 103 | 13 | 8 | 35 | 930 | 652 |
| 6. CO | | | | | | | 16 | 3 | 11 | 5 | 5 | | 1 | 1 | 43 | 29 |
| 7. CT | | | | | | | 27 | 15 | 21 | 18 | 15 | 3 | 1 | 4 | 110 | 99 |
| 8. DE | | | | | | | 3 | | | | 1 | | | | 4 | 0 |
| 9. DC | | | | | | | 1 | 1 | 1 | | | | | | 3 | 3 |
| 10. FL | | | | | | | 34 | 13 | 18 | 9 | 18 | 1 | 1 | 1 | 104 | 94 |
| 11. GA | | | | | | | 12 | 3 | 6 | | 2 | | | | 23 | 5 |
| 12. HI | | | | | | | | | | | | | | 1 | 1 | 3 |
| 13. ID | | | | | | | 1 | 1 | 1 | | | | | | 3 | 3 |
| 14. IL | | | | 1 | | | 76 | 25 | 41 | 32 | 45 | 3 | 1 | 13 | 231 | 225 |
| 15. IN | | | | | | | 25 | 8 | 14 | 7 | 12 | 3 | 3 | 5 | 87 | 66 |
| 16. IA | | | | | | | 11 | | 1 | 2 | 3 | | | | 19 | 18 |
| 17. KS | | | | | | | 13 | 2 | 8 | 4 | 3 | | | | 30 | 18 |
| 18. KY | | | | | | | 2 | 1 | 2 | 4 | 2 | 1 | | | 16 | 10 |
| 19. LA | | | | | | | 2 | 1 | | | 3 | 1 | 1 | | 9 | 1 |
| 20. ME | | | | | | | 3 | | | | | | | | 3 | 9 |
| 21. MD | | | | | | | 17 | 9 | 9 | 2 | 3 | | | 3 | 47 | 35 |
| 22. MA | | | | | | | 65 | 35 | 40 | 30 | 43 | 3 | 2 | 6 | 230 | 210 |
| 23. MI | | | | | | | 31 | 12 | 15 | 5 | 8 | | | 4 | 78 | 31 |
| 24. MN | | | | | | | 16 | 11 | 13 | 7 | 16 | | 1 | 4 | 69 | 50 |
| 25. MS | | | | | | | 2 | | 2 | 1 | 1 | | | | 6 | 4 |
| 26. MO | | | | | | | 23 | 2 | 2 | 6 | 7 | 2 | | | 42 | 27 |
| 27. MT | | | | | | | | | | | | | | | 0 | 0 |
| 28. NE | | | | | | | 3 | 3 | 1 | | 1 | 1 | | | 9 | 13 |
| 29. NV | | | | | | | 3 | 2 | | | | | | | 6 | 2 |
| 30. NH | | | | | | | 14 | 5 | 6 | 3 | 10 | 1 | 1 | 1 | 46 | 27 |
| 31. NJ | | | | | | | 119 | 34 | 63 | 39 | 35 | 2 | 1 | 7 | 341 | 249 |
| 32. NM | | | | | | | 9 | 5 | 3 | | 2 | 1 | | | 20 | 4 |
| 33. NY | | | | | | | 130 | 48 | 73 | 51 | 36 | 2 | 2 | 19 | 393 | 339 |
| 34. NC | | | | | | | 11 | 7 | 2 | 3 | 7 | 4 | | 2 | 39 | 26 |
| 35. ND | | | | | | | | | | | | | | | 0 | 0 |
| 36. OH | | 1 | | | | | 42 | 16 | 22 | 16 | 17 | | 4 | 2 | 132 | 93 |
| 37. OK | | | | | | | 11 | 4 | 7 | 4 | 1 | | | | 29 | 22 |
| 38. OR | | | | | | | 10 | 2 | 6 | 1 | | | | | 20 | 13 |
| 39. PA | | | | | | | 56 | 27 | 36 | 12 | 41 | 9 | 1 | 2 | 197 | 156 |
| 40. RI | | | | | | | 7 | 4 | 8 | 1 | 3 | | 1 | | 25 | 19 |
| 41. SC | | | | | | | 1 | | 2 | | 3 | | 1 | | 8 | 6 |
| 42. SD | | | | | | | | 1 | | 1 | 2 | | | | 4 | 4 |
| 43. TN | | | 1 | | | | 4 | 4 | 1 | 1 | 3 | 1 | | | 14 | 9 |
| 44. TX | | | | | | | 72 | 27 | 23 | 11 | 13 | 1 | 3 | 7 | 168 | 94 |
| 45. UT | | | | | | | 5 | 1 | 2 | 1 | 1 | | | | 12 | 7 |
| 46. VT | | | | | | | 2 | | | | 3 | | | | 5 | 3 |
| 47. VA | | | | | | | 13 | 3 | 3 | | 11 | 1 | | | 35 | 33 |
| 48. WA | | | | | | | 13 | 6 | 7 | 3 | 2 | | | 2 | 36 | 17 |
| 49. WV | | | | | | | | 1 | 2 | 1 | 1 | | | | 6 | 3 |
| 50. WI | | | | | | | 21 | 5 | 10 | 7 | 8 | 1 | | 2 | 37 | 39 |
| 51. WY | | | | | | | | | | | | | | | 0 | 0 |
| | 1 | 1 | 1 | 1 | | 1 | 1249 | 528 | 661 | 409 | 492 | 55 | 36 | 127 | 3828 | 2853 |

| | SIC 3678 | SIC 3679 |
|---|---|---|
| Dun & Bradstreet Total / Census Total | 5 / 92 | 3555 / 1840 |

| | 20-49 | 50-99 | 100-499 | 500-999 | 1000+ | Not shown | 0-9 | 10-19 | 20-49 | 50-99 | 100-499 | 500-999 | 1000+ | Not shown | D&B Total | Census Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Region I | | | | | | | 118 | 59 | 75 | 56 | 74 | 7 | 5 | 11 | 423 | 367 |
| II | | | | | | | 249 | 102 | 136 | 90 | 69 | 4 | 3 | 26 | 679 | 588 |
| III | | | | | | | 92 | 41 | 49 | 15 | 59 | 10 | 1 | 5 | 272 | 230 |
| IV | | | | | | | 68 | 31 | 34 | 23 | 37 | 8 | 3 | 6 | 208 | 173 |
| V | | 1 | | 1 | | | 209 | 77 | 115 | 74 | 104 | 7 | 9 | 30 | 625 | 524 |
| VI | 1 | | 1 | | | | 94 | 37 | 33 | 15 | 19 | 3 | 4 | 7 | 212 | 132 |
| VII | | | | | | | 50 | 8 | 12 | 13 | 16 | 3 | 0 | | 122 | 78 |
| VIII | | | | | | | 21 | 4 | 13 | 6 | 6 | | 1 | 1 | 52 | 36 |
| IX | 1 | | | | | 1 | 324 | 160 | 180 | 115 | 106 | 13 | 8 | 41 | 947 | 694 |
| X | | | | | | | 26 | 9 | 14 | 4 | 2 | | | 2 | 55 | 33 |
| National | 1 | 1 | 1 | 1 | | 1 | 1249 | 528 | 661 | 409 | 492 | 55 | 36 | 127 | 3828 | 2853 |

Both the overall differences in numbers between Dun and Bradstreet and the Census of Manufactures and the very low Dun and Bradstreet numbers for plants in SICs 3675, 3676, 3677 and 3678 indicate that their listing has not been updated to reflect the separation of these product groups from the pre-1972 SIC 3679. The inclusion of these new categories was initiated in the 1972 Census of Manufactures.

The value of using information from Table II-6 for making regional and state waste generation estimates based upon disaggregated employment is, for these reasons, low. A better data base on which the plant employment statistics can be disaggregated geographically is not available.

While available data does not allow reliable estimates for geographic distribution of employment, employment figures are a reasonably good measure of industry production as measured by value of shipments. Due to variations in raw material prices and in costs associated with process operations, correlations between employee numbers and value of shipments are likely valid only within a limited range of product types. For instance, competition between transformer manufactures would create a somewhat constant ratio of employees to value of shipments in SIC 3677 plants. The same ratio would not necessarily apply to plants manufacturing television picture tubes where material and energy costs are quite different.

Total employees: value of shipments and production employees: value of shipment ratios for the four-digit SICs are presented in Table II-7. These ratios have been used for estimating value of shipments from a few of the plants surveyed for this study which could not disclose their production figures but could give either total employment or production employment.

## GEOGRAPHIC DISTRIBUTION OF PRODUCTION

Due to the diversity of SIC 367 products, it appears that the best indicator of production distribution is value of shipments. This parameter is reported in the 1972 Census of Manufactures in two ways that could be used to describe production distribution. Total value of plant shipments are reported for plants according to their primary, four-digit SIC product and according to the state and census region in which the plant is located. Total value of plant shipments include values of primary products, secondary products and miscellaneous receipts. Alternatively, the value of product shipments of specific products is reported for some states and census regions regardless of the primary product SIC of the plants in which they were manufactured. Due to the requirement that the Department of Commerce not publish information which would disclose operational data for any single plant, neither source of data is complete for all census regions or states. However, the plant-related parameter, total value of plant shipments, is associated with data on the number of plants in most states. Numbers of plants in the States have been used here to extend the available value of shipments data to states where the Department of Commerce could not report hard data.

Total value of shipments is reported in the Census by four-digit SIC and state for $3,511 million of the $8,798 million per year (1972) for the entire industry. To extend the data the assumption was made that the state value of plant shipments can be estimated for each four-digit SIC by applying the formula:

$$\frac{\text{Number of plants in state}}{\text{Number of plants in census region}} \times \begin{array}{l}\text{Value of shipments}\\ \text{for census region}\end{array} = \begin{array}{l}\text{Value of shipments}\\ \text{for state}\end{array}$$

This extrapolation was not done: (1) for states with less than four plants classified in the primary SIC of concern; and (2) for states which did not have applicable regional value of shipments data.

Table II-8 presents both the firm value of shipments data from the 1972 Census of Manufactures and the extrapolated figures. Extrapolated data and state/SIC positions for which some data was presented in the Census are identified by the letter (D). Percentage of production covered by firm plus extrapolated values are given for each four-digit SIC and for the industry.

It is interesting to note for the states which have the greatest production that the ranking of state value of shipments for SIC 367 is not the same as the ranking for number of plants in each state. New York, which is second to California in number of plants by a large margin, had the highest value of shipments. Pennsylvania also had a large value of shipments for the number of plants. The average value of shipments per plant for the 10 states with the greatest production is given in Table II-9. High averages in New York and Pennsylvania may indicate that plants there are more highly integrated since larger plants, in general, contract out less work than smaller, more specialized plants.

## ECONOMIC TRENDS

The best index available to estimate industry production for SIC 367 and its four-digit SIC's for different years is value of industry shipments data adjusted by Wholesale Price Indexes, to reflect the changing value of the dollars that are purchasing electronic components. Wholesale Price Indexes convert current dollars for the month or year in question which have 1967 as the base year. While this adjustment does not account for changes in the production: value shipped ratio that would be due to mechanization, better management, design innovation and other non-cost factors, it does make value of shipments data for different years more comparable.

Figure II-2 presents historic and projected value of industry shipments for SIC 367 from 1958 through 1985. As noted in this figure, data for 1958, 1963, 1967 and 1972 came from the Department of Commerce Census of Manufactures. These numbers are based on the most comprehensive government surveys performed for the industry. Data for 1971 and 1973 are annual estimates based upon a more limited data base. Data for 1974, 1975, 1976 and 1985 are estimates made by the Bureau of Domestic Commerce, [10].

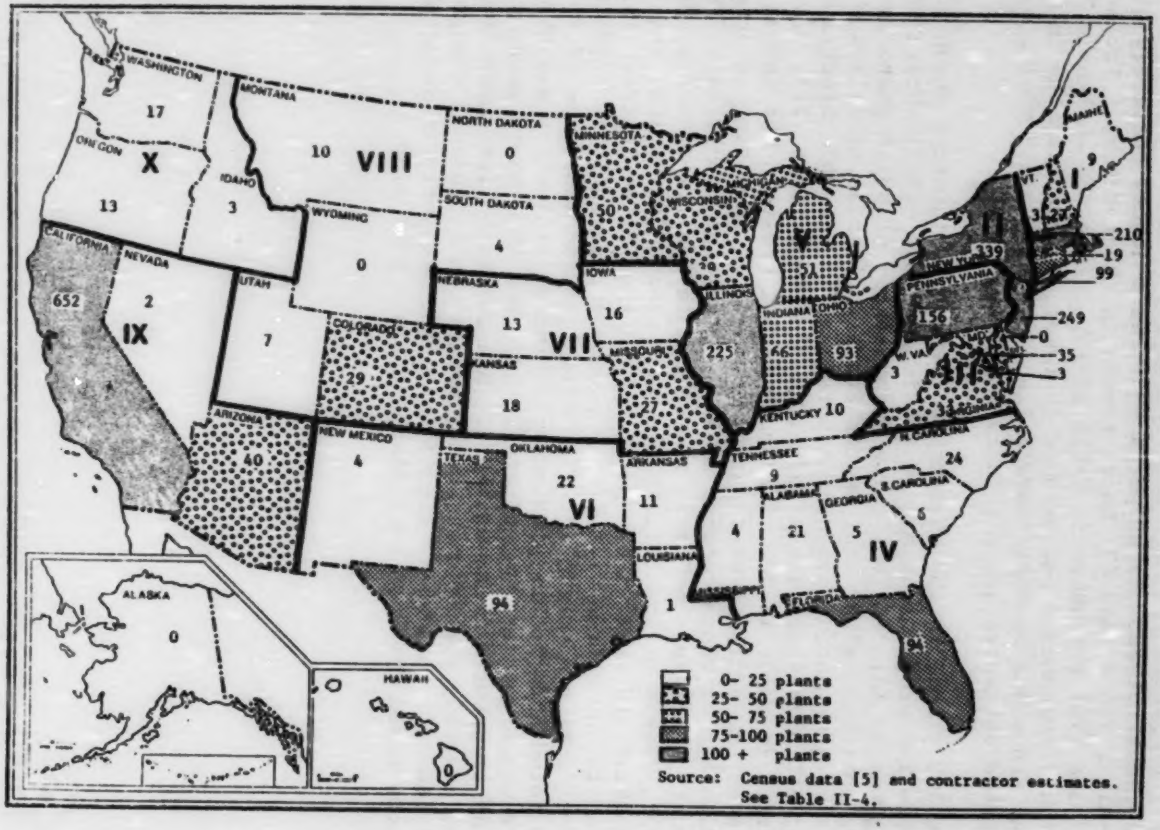
Wholesale Price Indexes as shown in Figure II-2 were used to deflate the value of industry shipments figures. Increases in the Wholesale Price Indexes for SIC 367 beginning in late 1973 generally occurred later and were of smaller magnitude than the WPI for all commodities. No change in the WPI for SIC 367 has been assumed for projections beyond 1975 [11].

Value of industry shipments projections at the four-digit SIC level have been made by the government only to 1976 [10]. However, estimates have been generated for the purposes of this report which reflect: (1) the total size of the industry projected for 1976 and 1985 by the Domestic and International Business Administration; (2) proportion of the industry currently shared by the nine four-digit SIC's; and (3) known trends in the industry. The estimates for 1975, 1977 and 1985 are shown in Table II-10. Since the Wholesale Price Indexes for electronic components was assumed to remain constant in the industry-wide projections and since economic data collected during plant visits was in 1975 dollars, these estimates are all in 1975 dollars.

Two major trends in the electronic components industry which would affect waste generation projections are growth in SIC 3674 - Solid State Devices and increasing use of foreign facilities for assembly of solid state devices whose parts are fabricated within the United States. Increasing reliance on semiconductors is supplanting production potential in SIC 3671 Electron Tubes - Receiving, SIC 3676 - Resistors and SIC 3675 - Capacitors [11]. These trends are reflected in Table II-10. Strong competition within the industry, especially in the rapidly expanding semiconductor segment, is resulting in some companies taking advantage of cheaper labor markets in foreign countries. Typically, a company with plants in the United States and in countries such as Mexico, North Korea, Taiwan or the Phillipines will produce parts that require highly skilled workers and supervisory personnel in the United States. These parts are shipped to the company's overseas plants for assembly in complex components or in end-of-line products [11]. The effect of increased use of foreign plants is not factored into future production estimates [10] which are the basis here for future waste generation estimates. 1977 and 1983 waste generation estimates would be reduced to an unquantifyable degree by increased foreign production or assembly operations. Other market and technology changes in this turbulent industry could have significant, but presently unpredictable, effects on the amounts and types of land-disposed waste generated.

FIGURE II-1

Number of SIC 367 Plants in Each State


WASHINGTON 17
OREGON 13
X
IDAHO 3
MONTANA 10
VIII
WYOMING 0
NORTH DAKOTA 0
SOUTH DAKOTA 4
CALIFORNIA 652
NEVADA 2
IX
UTAH 7
COLORADO 29
ARIZONA 40
NEW MEXICO 4
NEBRASKA 13
KANSAS 18
VII
IOWA 16
MISSOURI 27
MINNESOTA 50
WISCONSIN
ILLINOIS 225
INDIANA 66
MICHIGAN 51
V
OHIO 93
KENTUCKY 10
TEXAS 94
OKLAHOMA 22
VI
ARKANSAS 11
LOUISIANA 1
TENNESSEE 9
MISSISSIPPI 4
ALABAMA 21
GEORGIA 5
S.CAROLINA 5
N.CAROLINA 24
IV
FLORIDA 94
W.VA 3
VIRGINIA 33
III
MD
PENNSYLVANIA 156
NEW YORK 339
II
VT. 3
27
MAINE 9
I
210
19
99
249
0
35
3
ALASKA 0
HAWAII 0
0– 25 plants
25– 50 plants
50– 75 plants
75–100 plants
100 + plants

Source: Census data [5] and contractor estimates. See Table II-4.

## TABLE II-7

### Employee to Value of Shipment Ratios for the Four-digit SIC's - Electronic Components Values in terms of Number of Employees Per Million Dollars

| | Total Employees / Value of Shipments | Production Employees / Value of Shipments |
|---|---|---|
| 3671 | 49.5 | 41.2 |
| 3672 | 21.5 | 17.5 |
| 3673 | 42.8 | 25.7 |
| 3674 | 36.1 | 21.6 |
| 3675 | 62.1 | 50.5 |
| 3676 | 55.1 | 42.2 |
| 3677 | 66.8 | 54.0 |
| 3678 | 37.6 | 26.0 |
| 3679 | 33.1 | 22.7 |
| 367 | 38.1 | 26.4 |

SOURCE: 1972 Census of Manufactures

NOTE: These statistics were used to estimate annual value of shipments for surveyed plants which could provide production employee or total employee data but could not release data on value of shipments. Plant value of shipments are used in this study to extrapolate plant waste data to industry estimates.

## TABLE II-8

### Value of Shipments for the Nation, EPA Regions and States by Four-digit SIC and the Industry. Values are for Total Shipments from Plants Classified in the Designated Primary SIC's

| | | | 3671 | 3672 | 3673 | 3674 | 3675 | 3676 | 3677 | 3678 | 3679 | State Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | ALA | IV | | | | | (D) | | | | 16.0 W | 16.0 |
| 2. | AL | X | | | | | | | | | | |
| 3. | AZ | IX | | | | 55.0 W | (D) | | | | 21.4 W | 76.4 |
| 4. | ARK | VI | | | | | | | (D) | (D) | (D) | |
| 5. | CA | IX | | | 177.3 W | 742.6 W | 43.7 W | 42.3 W | 32.3 W | 59.0 W | 384.5 W | 1481.7 |
| 6. | CO | VIII | | | | | | (D) | | | 17.8 W | 17.8 |
| 7. | CN | I | | | 25.9 W | 7.7 | 28.8 W | (D) | 5.5 | 44.5 | 76.1 | 188.5 |
| 8. | DE | III | | | | | | | | | | |
| 9. | DC | III | | | | | | | | | (D) | |
| 10. | FL | IV | | | (D) | 151.4 W | (D) | (D) | 12.7 (D) | (D) | 82.8 | 246.9 |
| 11. | GA | IV | | | | | | | | | | |
| 12. | HI | IX | | | | | | | | | | |
| 13. | ID | X | | | | (D) | | | | | | |
| 14. | IL | V | | 129.8 W | (D) | 3.4 | (D) | 35.6 W | 62.1 | 57.9 W | 262.8 | 551.6 |
| 15. | IN | V | (D) | 81.1 W | | (D) | (D) | 42.8 W | 34.9 | (D) | 30.6 W | 209.4 |
| 16. | IA | VII | | | | | | (D) | 8.0 W | | 13.0 W | 21.0 |
| 17. | KS | VII | | | | | | | | | 13.1 | 13.1 |
| 18. | KY | IV | (D) | | | | | | | | (D) | |
| 19. | LA | VI | | | | | | | | | | |
| 20. | ME | I | | | | 14.7 W | (D) | | | | (D) | 14.7 |
| 21. | MD | III | | | | | | | | | 29.9 W | 29.9 |
| 22. | MA | I | (D) | | 86.6 W | 250.1 W | 19.2 W | 12.0 W | 6.9 W | 6.6 | 167.7 | 549.1 |
| 23. | MI | V | | | | 3.0 | | | 11.8 | (D) | 29.3 | 44.1 |
| 24. | MIN | V | | | | (D) | | | 12.0 W | (D) | 67.6 | 79.6 |
| 25. | MIS | IV | | | | | | | | | | |
| 26. | MO | VII | | | | 6.8 W | | | (D) | | 21.1 | 29.9 |
| 27. | MT | VIII | | | | | | | | | | |
| 28. | NB | VII | | | | | (D) | (D) | | | 11.1 W | 11.1 |
| 29. | NV | IX | | | | | | | | | | |
| 30. | NH | I | | | (D) | | (D) | 9.6 W | | (D) | 24.4 | 34.0 |
| 31. | NJ | II | (D) | (D) | 60.6 W | 26.6 | 12.8 | 36.1 W | 13.8 | (D) | 168.0 | 313.9 |
| 32. | NM | VI | | | | (D) | | | | | | |
| 33. | NY | II | | (D) | 25.9 W | 496.6 | 19.7 | 15.1 W | 48.8 | 87.8 | 1135.7 | 1829.6 |
| 34. | NC | IV | | | | | 34.2 | 35.0 | | | 11.8 W | 81.0 |
| 35. | ND | VIII | | | | | | | | | | |
| 36. | OH | V | (D) | 113.5 W | | 18.3 W | (D) | | 24.7 | 28.9 W | 57.4 | 242.8 |
| 37. | OK | VI | | | | | | | | (D) | 10.8 W | 10.8 |
| 38. | OR | X | | | | | | | (D) | | 8.9 W | 8.9 |
| 39. | PA | III | (D) | (D) | 34.6 W | 288.2 | 25.8 | 37.9 W | 26.5 | 81.5 W | 99.1 | 593.6 |
| 40. | RI | I | | | | 29.4 W | | | | (D) | 13.3 W | 42.7 |
| 41. | SC | IV | | | | | 48.6 W | | (D) | | | 48.6 |
| 42. | SD | VIII | | | | | | | (D) | | (D) | |
| 43. | TN | IV | | | | | (D) | | (D) | | | |
| 44. | TX | VI | | | | 235.5 W | (D) | (D) | | | 32.4 W | 267.9 |
| 45. | UT | VIII | | | (D) | (D) | | | | | | |
| 46. | VT | I | | | | 7.4 W | (D) | | | | | 7.4 |
| 47. | VA | III | | | (D) | 67.3 W | 23.3 | (D) | | | 35.6 | 126.2 |
| 48. | WA | X | | | | | | | | | 13.4 W | 13.4 |
| 49. | WV | III | | | | | | (D) | (D) | | | |
| 50. | WI | V | | | | | (D) | | 9.7 W | | 419.0 W | 58.7 |
| 51. | WY | VIII | | | | | | | | | | |
| Total from Table | | | 0 | 324.4 | 410.9 | 2404.0 | 256.1 | 264.4 | 309.7 | 366.2 | 2924.6 | 7260.3 |
| National Total from Census of Mfg. | | | 230.4 | 696.5 | 479.3 | 2686.9 | 445.8 | 372.2 | 353.5 | 491.1 | 3041.6 | 8798.1 |
| % included in Table | | | C | 46.6 | 85.7 | 89.4 | 57.4 | 71.0 | 87.6 | 74.4 | 96.1 | 82.5 |

EPA Region (from data in Table only)

| | 3671 | 3672 | 3673 | 3674 | 3675 | 3676 | 3677 | 3678 | 3679 | State Total |
|---|---|---|---|---|---|---|---|---|---|---|
| I | | | 112.5 | 309.3 | 48.0 | 21.6 | 12.4 | 51.1 | 296.2 | 836.4 |
| II | | | 86.5 | 523.2 | 32.5 | 46.5 | 62.6 | 87.8 | 1303.7 | 2142.8 |
| III | | | 101.9 | 311.5 | 25.8 | 37.9 | 26.5 | 81.5 | 164.6 | 749.7 |
| IV | | | | 151.6 | 34.2 | 83.6 | 12.7 | | 110.6 | 392.5 |
| V | | 324.4 | | 24.7 | | 78.4 | 155.2 | 86.8 | 516.7 | 1186.2 |
| VI | | | | 235.5 | | | | | 43.2 | 278.7 |
| VII | | | | 6.8 | | | 8.0 | | 58.3 | 73.1 |
| VIII | | | | | | | | | 17.8 | 17.8 |
| IX | | | 177.3 | 797.6 | 43.7 | 42.3 | 32.3 | 59.0 | 405.9 | 1558.1 |
| X | | | | | | | | | 22.3 | 22.3 |
| | | | | | | | | | | 7257.6 |

LEGEND:

| Entry | Interpretation |
|---|---|
| Blank | - No data available |
| (D) | - Data provided in Census insufficient for extrapolation |
| 18.3 W | - Value of shipments estimated by means described in text |
| 25.8 | - Value of shipments presented in 1972 Census of Manufactures |

Values in Millions of Dollars

## TABLE II-9

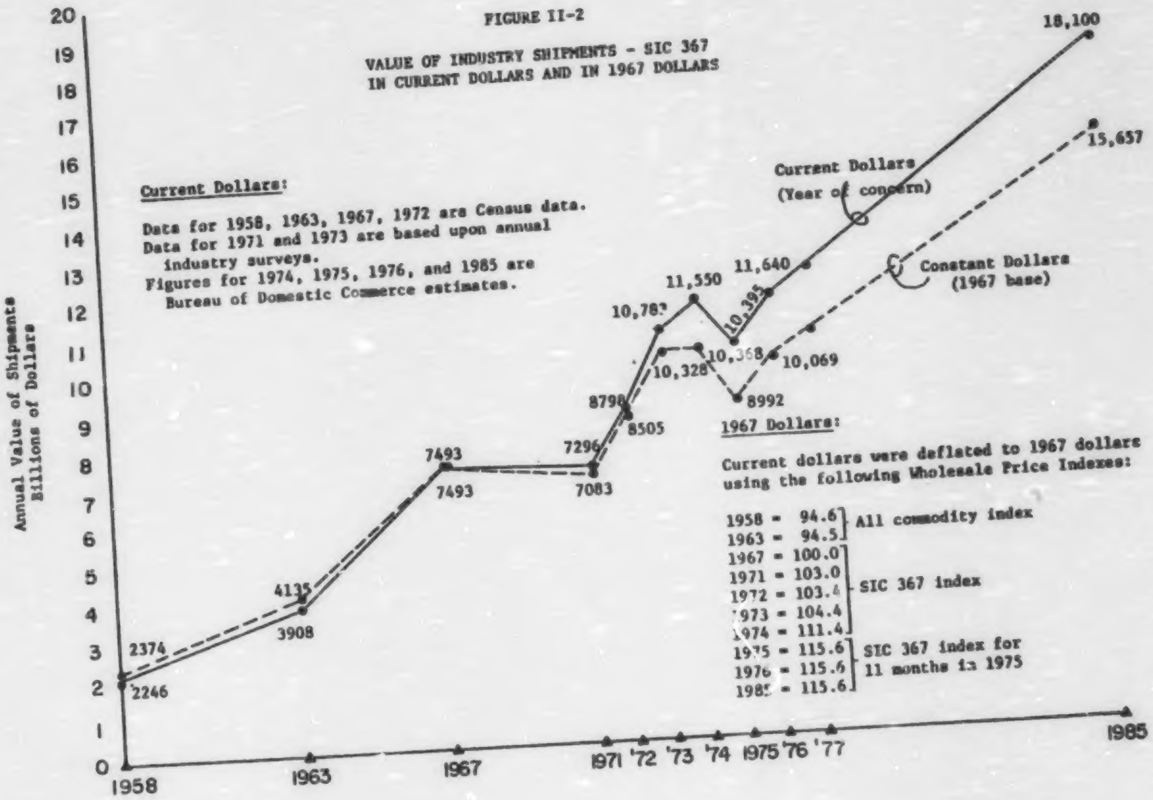
### Average Value of Shipments Per Plant for the 10 States with Largest Production

| | SIC 367 Value of Shipments ($ million/year) | Number of Plants | Value of Shipment per plant ($ million/year) |
|---|---|---|---|
| New York | 1829.6 | 339 | 5.4 |
| California | 1481.7 | 652 | 2.3 |
| Pennsylvania | 593.6 | 156 | 3.8 |
| Illinois | 551.6 | 225 | 2.4 |
| Massachusetts | 549.1 | 210 | 2.6 |
| New Jersey | 313.9 | 249 | 1.3 |
| Texas | 267.9 | 94 | 2.8 |
| Florida | 246.9 | 94 | 2.6 |
| Ohio | 242.8 | 93 | 2.6 |
| Indiana | 209.4 | 66 | 3.2 |

SOURCE: 1972 Census of Manufactures

FIGURE II-2

VALUE OF INDUSTRY SHIPMENTS - SIC 367
IN CURRENT DOLLARS AND IN 1967 DOLLARS



**Current Dollars:**

Data for 1958, 1963, 1967, 1972 are Census data.
Data for 1971 and 1973 are based upon annual industry surveys.
Figures for 1974, 1975, 1976, and 1985 are Bureau of Domestic Commerce estimates.

**1967 Dollars:**

Current dollars were deflated to 1967 dollars using the following Wholesale Price Indexes:

1958 = 94.6 } All commodity index
1963 = 94.5 }
1967 = 100.0 }
1971 = 103.0 }
1972 = 103.4 } SIC 367 index
1973 = 104.4 }
1974 = 111.4 }
1975 = 115.6 } SIC 367 index for
1976 = 115.6 } 11 months in 1975
1985 = 115.6 }

# SECTION III

# WASTE CHARACTERIZATION

## INTRODUCTION

The products of the electronic components manufacturing industry are typified by a high degree of design diversity. The manufacturing processes used to achieve the product designs are numerous and not consistently related to design. While the products and the process designs of the industry can be grouped according to function, there is little direct correlation between product groups (as defined by the four-digit SIC's) and wastes generated from their manufacture. There is better correlation between manufacturing process used and wastes generated. However, since manufacturing processes often vary widely even within restricted product groups, the correlation between available industry employment, plant size, and production data on the one hand, and wastes on the other, cannot be made on the basis of manufacturing process. For these reasons, waste streams are defined for this study according to the general chemical nature of process wastes actually recognized in the plants surveyed. This approach is facilitated by the practice common in the industry of segregating some of their process wastes. Discussion of treatment and disposal technology is also aided by using waste-defined waste streams.

Ten process waste categories with potential for final disposal in or on the land were recognized during the 22 plant visits made for this study:

- Halogenated Solvents
- Non-halogenated Solvents
- Wastewater Treatment Sludges
- Plastics
- Oils
- Paint Wastes
- Metal Scrap
- Concentrated Cyanides
- Concentrated Acids or Alkalies
- Plant trash (includes miscellaneous process wastes)

The nature and process sources of these waste streams will be discussed in this section. Estimates of industry-wide quantities have been made for the first six waste categories for 1975, 1977 and 1983. Hazardous constituents of the waste streams, as defined by considerations discussed below, have also been estimated. Results of these estimations are presented in Tables III-1-3. Disaggregation by state and EPA region of waste streams containing significant amounts of hazardous constituents and of the hazardous constituents themselves is discussed in this section. Results of the disaggregations are presented in Appendix B.

Metal scrap, concentrated cyanides, and concentrated acids and alkalies are not land-disposed in significant quantities by the industry. Metal scrap, except beryllium oxide wastes, is nearly always sold to metal reclaimers. The

TABLE III-1

ELECTRONIC COMPONENTS MANUFACTURING
SIC 367
PROCESS WASTE GENERATION
1975 NATIONAL TOTALS
(kkg/year)

| Waste Stream | Total Waste (Wet Wt.) | Total Waste (Dry Wt.) | Total Potentially Hazardous Waste (Wet Wt.) | Total Potentially Hazardous Waste (Dry Wt.) | Total Hazardous Constituents (Dry Wt.) Flammable Solvents* | Total Hazardous Constituents (Dry Wt.) Heavy Metals | Total Hazardous Constituents (Dry Wt.) Fluorides | Total Hazardous Constituents (Dry Wt.) Oils |
|---|---|---|---|---|---|---|---|---|
| Halogenated Solvents | 10,780 | 10,780 | 4,620 | 4,620 | 0 | .046 | 0 | 1.124 |
| Non-Halogenated Solvents | 15,400 | 15,400 | 15,400 | 15,400 | 13,860 | .062 | 0 | 1.540 |
| Wastewater Treatment Sludges | 27,720 | 5,390 | 27,720 | 5,390 | 0 | 47.740 | 28 | 0 |
| Plastics | 4,620 | 4,620 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lubricating & Hydraulic Oils | 1,540 | 185 | 1,540 | 185 | 0 | .462 | 0 | 80.080 |
| Paint Wastes | 200 | 200 | 200 | 200 | 100 | .046 | 0 | 0 |
| TOTALS | 60,260 | 36,575 | 49,480 | 25,795 | 13,960 | 48.356 | 28 | 82.744 |

*Flash Point less than 100°F.

## TABLE III-2

## ELECTRONIC COMPONENTS MANUFACTURING
SIC 367
PROCESS WASTE GENERATION
1977 NATIONAL TOTALS
(kkg/year)

| Waste Stream | Total Waste | | Total Potentially Hazardous Waste | | Total Hazardous Constituents (Dry Wt.) | | | |
|---|---|---|---|---|---|---|---|---|
| | (Wet Wt.) | (Dry Wt.) | (Wet Wt.) | (Dry Wt.) | Flammable Solvents* | Heavy Metals | Fluorides | Oils |
| Halogenated Solvents | 13,860 | 13,860 | 6.160 | 6,160 | 0 | .055 | 0 | 1.417 |
| Non-Halogenated Solvents | 18,480 | 18,480 | 18,480 | 18,480 | 16,940 | .077 | 0 | 1.848 |
| Wastewater Treatment Sludges | 50,820 | 10,780 | 50,820 | 10,780 | 0 | 100.100 | 62 | 0 |
| Plastics | 5,390 | 5,390 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lubricating & Hydraulic Oils | 2,310 | 231 | 2,310 | 231 | 0 | .570 | 0 | 110.880 |
| Paint Wastes | 246 | 246 | 246 | 246 | 123 | .062 | 0 | 0 |
| TOTALS | 91,106 | 48,987 | 78,016 | 35,897 | 17,063 | 100.864 | 62 | 114.145 |

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*Flash Point less than 100°F.

## TABLE III-3

## ELECTRONIC COMPONENTS MANUFACTURING
SIC 367
PROCESS WASTE GENERATION
1983 NATIONAL TOTALS
(kkg/year)

| Waste Stream | Total Waste (Wet Wt.) | Total Waste (Dry Wt.) | Total Potentially Hazardous Waste (Wet Wt.) | Total Potentially Hazardous Waste (Dry Wt.) | Total Hazardous Constituents (Dry Wt.) Flammable Solvents* | Total Hazardous Constituents (Dry Wt.) Heavy Metals | Total Hazardous Constituents (Dry Wt.) Fluorides | Total Hazardous Constituents (Dry Wt.) Oils |
|---|---|---|---|---|---|---|---|---|
| Halogenated Solvents | 20,020 | 20,020 | 9,240 | 9,240 | 0 | .077 | 0 | 2.002 |
| Non-Halogenated Solvents | 24,640 | 24,640 | 24,640 | 24,640 | 23,100 | .092 | 0 | 2.464 |
| Wastewater Treatment Sludges | 70,840 | 15,400 | 70,840 | 15,400 | 0 | 138.600 | 77 | 0 |
| Plastics | 7,700 | 7,700 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lubricating & Hydraulic Oils | 3,080 | 308 | 3,080 | 308 | 0 | .785 | 0 | 154.0 |
| Paint Wastes | 308 | 308 | 308 | 308 | 154 | .077 | 0 | 0 |
| TOTALS | 126,588 | 68,376 | 108,108 | 49,896 | 23,254 | 139.631 | 77 | 158.466 |

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*Flash Point less than 100°F.

cyanides, acids and alkalies are typically oxidized and neutralized by conventional methods of wastewater treatment and produce no residue for land disposal. Only one of the twenty-three surveyed plants land disposed of concentrated cyanides or acids. The only hazardous waste recognized in the miscellaneous category was one containing polychlorinated biphenyls. The low frequency at which these process wastes were land-disposed by the surveyed plants resulted in insufficient data to support extrapolation to prevent area (SIC) or industry-wide levels.

## CRITERIA FOR THE DETERMINATION OF A POTENTIALLY HAZARDOUS WASTE

There are many definitions of "hazardous materials" in use today. They are variously designed for application in implementing the Clean Air Act, the Longshoremen's and Harbor Worker's Compensation Act, and Department of Transportation regulations. Others are built into pending legislation on solid waste disposal, and still others have been posed for purposes of earlier EPA hazardous waste studies relating to other industries. The two considerations, stated or implied, most common to all of them are the potential for acute or chronic adverse effects. This concept is also inherent in the hazardous criteria applied in this report.

One definition of "hazardous waste" in rather wide use is any waste or combination of wastes which pose a substantial present or potential hazard to human health or living organisms because such wastes are lethal, non-degradable, or persistent in nature; may be biologically magnified; or may otherwise cause or tend to cause detrimental cumulative effects. In interpreting this definition in its Report to Congress, Disposal of Hazardous Wastes [12], submitted in accordance with the Solid Waste Disposal Act, EPA established five categories of hazardous wastes. These are: toxic chemical, flammable, biological, radioactive, and explosive. The wastes generated by SIC 367 plants fall within the first two of these categories. No wastes are produced which meet the definitions of the radioactive, explosive, or biological categories set forth in the report.

Toxicity is defined in the Report to Congress as the ability of a waste to produce injury upon contact with or accumulation in a susceptible site in or on the body of a living organism. Toxicity, as it applies to the wastes of these industries, may be manifested in several ways. A corrosive waste may produce dermal irritation, an acute toxic effect. This type of waste may also be involved in long range situations because of interaction with metals or other wastes. Genetic change and bioconcentration are also long term effects which are not immediately discernible. The remaining manifestations of toxicity, ranging from minor systemic or local injury to death, are grouped under the umbrella term of "toxicity" for the purposes of this report.

While these effects, in the usual use of the term, are frequently exhibited in acute form, the effects which may result from the wastes of these industries are most likely to be long term, chronic effects. This is because wastes are produced which by almost any definition must be classified as potentially hazardous, but the quantities generated are unlikely to create acute situations in the ambient environment.

The degree of flammability of a waste is rather easily established as discussed below, but most toxic effects are not as readily measured.

## Toxicity

Within the scope of this project, assessment of whether wastes may present a potential hazard due to toxic effects must be based on available information and evidence generated by experts in the toxicological field. The body of toxicological literature, however, suffers certain deficiencies for the purposes of this project. The most serious of these is that it is nearly all occupationally or laboratory oriented. Correlations between concentrations of substances and morbidity and mortality data are scarce, and frequently an episode — ranging from simple irritation to death -- is described without reference to the amount of the compound which engendered it. In the few cases where this information is given, however, it usually documents toxic responses to higher concentrations than levels which could be expected to accrue from deposition of relatively small quantities of these substances in a land disposal operation. Few epidemiological facts are available so that information developed on the basis of occupational or laboratory exposure must be substituted.

The literature is replete with descriptions and documentation of the toxicity of elemental substances, but reliable information on certain specific compounds used by manufacturing plants within SIC 367 is sparse or apparently nonexistent on some materials which have only recently come into use. In some cases where data are available, multiple references are in conflict with one another.

Because of these constraints on documenting the chronic long term toxicity of compounds at various concentrations, it was decided to accept the Federal Water Quality Criteria [14] as the basis for assessing toxicity of process waste constituents. Process waste constituents which are present in soluble form in a waste or which leach in a concentration which exceeds the relevant criteria renders the waste potentially hazardous. The revision of the criteria under a new title, Quality Criteria for Water, is not yet completed, although draft information is available which reflects current thinking.

Data have been developed through laboratory leachate tests performed on waste samples collected at surveyed plants to support this approach. These are discussed below. It is a conservative approach and is based more on unknown factors than known ones with regard to the fate of these compounds in a land disposal operation. In the absence of an accurate gauge of their behavior under all environmental conditions, including synergism or inhibition, this narrow criterion appears to be a necessary safeguard against improper disposal. The criterion may result in the classification of some wastes as toxic which may not reach harmful concentrations in water leachate or runoff as a result of unsecured land disposal. For instance, sludges resulting from chemical precipitation of electroplating wastewaters may not release harmful concentrations of heavy metal ions in a landfill unless saturated by ground water or disposed along with acid wastes. Oils disposed of in drums may leak into the landfill over time but absorption and adsorption by fill dirt or other material may contain the oils adequately. As more data are developed on the long-term behavior of these substances in landfill situations, the strict criterion applied here could be subject to revision.

An acute toxic criterion applicable to electronic components manufacturing wastes is somewhat easier to document since it is more closely akin to occupationally-oriented concentrations. This is the corrosivity/dermal irritation criterion which, for purposes of this study, has been set at a pH of less than 5.0 and greater than 9.0, which are widely accepted safety ranges [14]. The intensity of the local and secondary complications, however, is more directly related to the concentration of the corrosive substance than to the volume or "dose" [15].

Bioconcentration may be defined as the selective concentration, or storing, of a specific chemical species by an organism. This phenomenon occurs in organisms ranging from water-borne microorganisms to humans. An organism's own chemistry will determine which substances it will accumulate and in what quantities.

While there is still a great deal to be learned about this process, there is ample evidence to show that several substances contained in the wastes from the manufacture of electronic components can be retained and stored by organisms up to harmful levels. These include cadmium, lead, mercury, and polychlorinated biphyenyls (PCB's) [16-23]. Thus, the entry of any amount of these substances into the environment is undesirable from the standpoint of the potential long-term hazards. However, cadmium, lead, and mercury are naturally present in at least trace amounts in many materials which become wastes, and PCB's have become widely disseminated in recent years. This being the case, the bioconcentration criterion for use in this report is that any measurable amount of these substances in a waste results in a hazardous designation.

### Flammability

The second criterion applied to wastes of the subject industries in determining their hazardous nature is the measure of flammability. Any waste with a flash point of 38°C (100°F) or less as measured by the Tag Open Tester is deemed a potential acute hazard. This is the limit which is used by the Department of Transportation to designate hazardous flammable solvents which require a red label warning.

The application of the measure of flammability to specific pure organic solvents is quite precise. This information is widely available in chemical and supplier literature. The flash point of mixed solvents as well as solvent-laden wastes is not as well established although a new test procedure has been developed and has been implemented to test the flash point of selected wastes [25]. For purposes of this study, any mixture of waste organic solvents with a flash point of 38°C (100°F) or below is considered potentially hazardous. This is the same criteria for flammability used by the U. S. Department of Transportation [41].

## DEFINITION OF POTENTIALLY HAZARDOUS WASTE STREAMS

A hazardous waste stream emanating from SIC 367 plants is defined as one which meets one or more of the following criteria:

| Hazard | Criteria for Waste Streams |
|---|---|
| Flammability | Flashpoint less than 38°C (100°F) [41] |
| Corrosivity/dermal irritation | pH less than 5.0 or greater than 9.0 |
| Toxicity | Raw waste or water leachate of a waste contains a constituent exceeding maximum contaminant level of Federal Water Quality Criteria [14] |
| Bioconcentration | Contains cadmium, lead, mercury, or PCB, in any detectable concentration |

The waste streams of these industries necessitate this broad definition. In some cases, a hazardous constituent accounts for the bulk of the waste stream or is the only component. In others, hazardous constituents account for a much smaller portion of the total waste stream, but are distributed throughout and cannot be segregated in waste handling.

When waste streams are neutralized, equalized, or otherwise chemically treated on the premises to the extent that they no longer meet any of the above criteria and are mechanically handled in the process, they are not considered potentially hazardous waste streams for disposal.

## Sampling Techniques and Analytical Methods

In order to develop new information on the waste streams of these industries to support hazardous/non-hazardous classifications, samples were collected at surveyed plants. The selection of the sample(s) to be taken was left to the discretion of the survey team since each plant is different in terms of process and raw material usage. However, the general guidelines were that: (1) the wastes should be destined for land disposal or incineration, and (2) they should be generated in relatively significant quantities (usually defined as more than 190 liters (50 gallons) per year). As a result of this plus waste availability, the waste streams collected varied from one facility to another.

The samples are all grab samples and represent the characteristics of a waste only at the time it was taken. Sixteen samples of both liquid and solid materials were analyzed.

The analytical methods employed are described in detail in Appendix C. Briefly, the methodology was as follows:

- Metals - atomic absorption spectroscopy
- Oil and Grease - hexane extraction
- $H_2O$ - Karl Fischer titration

Certain constituents of the samples were analyzed both as the samples were received and as they were leached with distilled water. These constituents were metals including cadmium, chromium, copper, iron, lead, zinc, nickel, and manganese. These metals were chosen based on: (1) their hazardous nature, and (2) the likelihood of finding them in detectable concentrations in the waste streams.

## WASTE GENERATION: RAW MATERIALS, MANUFACTURING PROCESSES AND WASTE SOURCES

The composition and quantity of individual process wastes result from raw materials usage, types of manufacturing processes and the sequence of manufacturing processes (process flow). Materials, processes and process flows are, in turn, determined by product and process design. As stated previously, there is no consistent industry-wide relationship between product design and manufacturing process design. Competition based largely upon innovative design enforces product and process diversity. Design changes in traditional components such as electron tubes, resistors and transformers appear to be intended primarily to improve component reliability and secondarily to reduce costs. In product areas where the product technology has not yet matured, such as semiconductors, complex components (two or more components assembled into a single unit) and recently developed components which have not yet realized high-volume production, design changes appear to be intended to improve component functions primarily and reliability secondarily. New electronic components have been developed continuously, particularly since World War II.

Because general relationships cannot be described between product areas (SIC's) and process wastes, the approach used here in describing the wastes of the industry is empirical. Data gathered during 22 plant visits and contained in one report provided by a plant not visited has been assumed to be representative of the industry. Plants were selected for the survey according to the following criteria in order that the group be as representative of the industry as possible and also yield the maximum amount of data:

- Product representation was achieved by surveying a number of plants within a product area (four-digit SIC) proportional to the value of shipments of that part of the industry. 19[illegible] Census data [5] was the base for determining the proportions.

- Geographic representation was achieved by surveying a number of plants within each Census region proportional to the number of electronic component manufacturing plants in that region. The Census regions are those groups of states used by the Department of Commerce for industrial surveys.

- Whenever feasible, plants with the most highly integrated (least amount of jobbing work out) operations were selected for survey. This resulted in an average value of shipments per plant for the surveyed plants, $16.9 million, that was four times the average value of shipments per plant for the industry, $4.2 million [10]. This bias toward the larger, more highly integrated plants was established for the purpose of maximizing number of manufacturing processes and wastes observed for a given number of plants. One result of this bias is thought to be a slight overestimation of waste volumes for the industry as a whole because, in general, the plants visited were generating all of the wastes related to produce manufacture, whereas smaller shops would have some of the product wastes generated by a job shop. There is no data available on the amount of work jobbed out by smaller plants. Reduction of the waste quantity estimates according to the degree of jobbing is not feasible, therefore.

The distribution of surveyed plants by product and by geographic location is shown in Table III-4. It is noteworthy that the target number of plants for this study, 25, was not achieved due to industry reluctance to participate voluntarily in this study. These companies which did allow surveys were exceptional in this regard.

Raw materials, common manufacturing processes and wastes of the electronic components manufacturing industry are described in the following sections. Example process flow diagrams for five major product areas are presented at the end of this section which show the relationships between raw materials, manufacturing processes, and wastes.

## Raw Materials

The list of raw materials recognized during the twenty-two plant visits includes ninety-plus materials that fall into ten categories according to chemical composition. The categories and materials are listed in Table III-5 along with their most common function(s). Only those materials are included that either; (1) were used, in whatever amount, in a variety of products or (2) were significant to the manufacture of at least one product. The type of use in the industry, whether general to several products or significant to one or a few products and whether incorporated into the product or just necessary to processes, is also noted for the materials in Table III-5.

This list cannot be considered inclusive for the industry. Product design varies considerably within product groups, even for such established components such as resistors, capacitors and electron tubes. Material composition, both product and non-product, is often considered a trade secret so that materials found in some plants may be dissimilar from materials used for the same product in another plant. Many low-volume and recently developed electronic components, where product design would vary even more than for the established components, have not even been recognized in this survey. It is probable that the raw materials list for electronic components manufacturing would increase in direct proportion to the number of plants visited until a great number of plants were included.

Nevertheless, because the method of selecting plants for the survey was oriented toward (1) including as many product types as possible and (2) including mainly large, well integrated plants, most of the commonly used and many of the waste-significant (high volume or high hazard potential) materials have been recognized during the survey and are included in Table III-5.

The ten material categories are discussed below. Significant properties which make the categories useful to the industry, or which result in a recognizable hazard potential are emphasized.

# TABLE III-4

## DISTRIBUTION OF SURVEYED PLANTS BY GEOGRAPHIC LOCATION - CENSUS REGIONS AND EPA REGIONS

| | Census Regions | | | | | EPA Regions | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SIC | North-east | North Central | South | West | Total | I | II | III | IV | V | VI | VII | VIII | IX | X |
| 3671 | | | | | 0 | | | | | | | | | | |
| 3672 | | 1 | 1 | | 2 | | 1 | | 1 | | | | | | |
| 3673 | 2 | | | 1 | 3 | 1 | | | | 1 | | | | 1 | |
| 3674 | 1 | | 1 | 3 | 5 | | 1 | 1 | | | | | | 3 | |
| 3675 | 1 | | | | 1 | | | 1 | | | | | | | |
| 3676 | 1 | | 1 | | 2 | | | 2 | | | | | | | |
| 3677 | | 1 | | | 1 | | | | | 1 | | | | | |
| 3678 | 1 | 1 | | | 2 | | | | | 1 | | | | | |
| 3679 | 2 | 2 | 1 | 2 | 7 | | 2 | | | 1 | 1 | 1 | | 2 | |
| | | | | | 23 | | | | | | | | | | |

## TABLE III-5

## RAW MATERIALS IN ELECTRONIC COMPONENTS MANUFACTURING

| Group | Material | Function | Usage |
|---|---|---|---|
| Metals | Gold | Conductive, protective coating | General use, minor amounts |
| | Silver | Conductive, protective coating | General use, minor amounts |
| | Platinum | Incorporated in capacitors for conductive prop. | Specialized - 3675 |
| | Palladium | Incorporated in capacitors for conductive prop. | Specialized - 3675 |
| | Solder: Pb/Sn | Lead attachments | General |
| | Aluminum | Metal vacuum coating; wire; structural | General |
| | Silicon | Substrate for semiconductors and int. circuits | Specialized - 3674 |
| | Stainless Steel | Structural and conductive metal | General |
| | Kovar metal | Structural and conductive metal | General |
| | Copper stock | Structural and conductive metal | General |
| | Copper wire | Conductive metal | General |
| | Brass | Structural and conductive metal | Specialized - 3673 |
| | P-Bronze | Structural and conductive metal | Specialized - 3673 |
| | Tungsten | Heating element for vacuum metalizing | Non-product |
| | Molybedenum | Current carrier for vacuum metalizing | Non-product |
| | Nickel | Conductive, protective coating; provides strength and corrosion resistance in alloys | General |
| | Chromium | Conductive, protective coating; provides strength and corrosion resistance in alloys | General |
| | Beryllium | Windows for X-ray tubes | Specialized - 3673 |
| | Be/Cu alloy | Electrical contacts | Specialized - 3673 |
| | Chromium cyanide | Source of chromium for electroplating | General |
| Metal Salts | Copper cyanide | Source of copper for electroplating | General |
| | Silver cyanide | Source of silver for electroplating | General; minor amounts |
| | Gold cyanide | Source of gold for electroplating | General; minor amounts |
| | Rhodium sulfate | Source of rhodium for electroplating | General; minor amounts |
| | Nickel chloride | Source of nickel for electroplating | General |
| | Nickel sulfate | Source of nickel for electroplating | General |
| | Sodium cyanide | Metal cleaner for electroplating | General |
| | Potassium cyanide | Metal cleaner for electroplating | General |
| | Potassium stannate | Source of tin for electroplating | General |
| | Zinc sulfide | Phosphor in black & white and color TV tubes | Specialized - 3672 |
| | Zinc-cadmium sulfide | Phosphor in black & white and color TV tubes | Specialized - 3672 |
| | Zinc stearate | Binder for products formed from powders | Specialized - 3672 and Ferrites |
| | Ammonium dichromate | Component of color TV picture tube screen photoresist | Specialized - 3672 |
| | Yttrium oxide | Phosphor in color TV tubes | Specialized - 3672 |
| Metal Oxides and Carbonate | Cadmium oxide | Source of cadmium for electroplating | Specialized - 3673 |
| | Lead oxide | Used in making glass/glass seals (fritting) | Specialized - 3672 |
| | Titanium oxide | Component of carbon-core resistors | Specialized - 3676 |
| | Sand | Component of carbon-core resistors | Specialized - 3676 |
| | Barium Carbonate | Coating on electron tube cathodes | Specialized - 3671 & 3672 |
| | Strontium carbonate | Coating on electron tube cathodes | Specialized - 3671 & 3672 |
| | Calcium carbonate | Coating on electron tube cathodes | Specialized - 3671 & 3672 |
| | Iron, Zinc, Magnesium, Lead and Strontium oxides | Components of ferrites and permanent magnets | Specialized - Ferrites |
| | Magnesium, Ammonium, Calcium, and Nickel carbonates | Components of ferrites and permanent magnets | Specialized - Ferrites |
| | Aluminum oxide | Sapphire crystal growing, semiconductor glassivation and grit blasting | Specialized - 3674 and Crystals |
| | BeO ceramic | Insulator for high-temperature uses | Specialized - 3673 |
| | Barium titanate | Ferroelectric ceramics | General |
| Glass | Structural glass | TV tube and receiving tube bodies; hermetic seals for other components | General |
| | Specially formulated glasses | Coating on some semiconductors; photoconductors; windows in special purpose tubes | Specialized - 3673 & 3674 |
| Plastics | Silver epoxy | Adhesive, sealant and electronic conductor | Possibly general - limited amt. |
| | Thermosetting plastics | Encapsulation of components | General |
| | 2-part epoxy resins | Encapsulation of components | General |
| | Silicone/Rubber | Encapsulation of components | General |
| | Resin shields | Protective lining in TV tubes | Specialized - 3672 |
| Paints and Organic Coatings | Epoxy-based paints | Protective covering and labeling | General |
| | Oil-based paints | Protective covering and labeling | General |
| | Lacquers and varnishes | Protective covering insulation & impregnation | General |
| | Graphite paint | TV tube painting | Specialized - 3672 |
| | Polychlorinated biphenols | Dielectric fluid in transformers and capacitors (not found in surveyed plant). Impregnation of carbon-core resistors. | Specialized - 3675, 3676, & 3677. |

## Table III-5 - Cont'd.

| Group | Material | Function | Usage |
|---|---|---|---|
| Oils | Cutting oils | Coolant and lubricant in grinding, cutting, and polishing operations. Normally mixed with high proportion of water | General - non-product |
| | Mineral oil | | |
| | Hydraulic oils | Energy transfer in machinery used for material forming and material removal | General - non-product |
| | Zero-sulfur oil | Filling some special purpose electron tubes | Specialized - 3673 |
| Chlorinated Solvents | Trichloroethylene | Vapor and immersion degreasing | General |
| | 1,1,1 Trichloroethane | Vapor and immersion degreasing | General |
| | Perchloroethylene | Vapor and immersion degreasing | General |
| | Trifluorotrichloroethane | Vapor and immersion degreasing and drying | General |
| | Methylene chloride | Paint and resin stripping | Specialized - 3672 |
| Non-chlorinated Solvents | Methyl alcohol | Immersion degreasing and drying; vehicle for photoresist | General |
| | Isopropyl alcohol | Immersion drying | General |
| | Polyvinyl alcohol | Vehicle for graphite paint & photo resist | Specialized - 3672 |
| | Ethyl acetate | Vehicle for graphite paint & photo resist | Specialized - Ferrites |
| | n-butyl acetate | Photoresist stripping | Specialized - 3674 |
| | Xylene | Vehicle for photoresist and epoxy resin paint | General |
| | Toluene | Vehicle for acrylic lacquer; cleaning used picture tubes; vehicle for metal oxides in magnetic tape manufacturing. | |
| | Acetone | Immersion drying and degreasing; paint & organic coating equipment cleaner | General |
| | Methyl ethyl ketone | Plastics cleaning | General |
| | Cyclohexanone | Vehicle for metal oxides in magnetic tape manufacturing | Specialized - Magnetic Tape |
| | Stoddard solvent | Equipment maintenance | General |
| Other Raw Materials | Graphite | Component conductive paint and carbon-core resistors | Specialized - 3672 & 3676 |
| | Carbon | Component of carbon-core resistors | Specialized - 3676 |
| | Asbestos | Parts wrapping | Specialized |
| | Silicon carbide | Abrasive | Specizlized - crystals |
| | Arsine, diborane, & phosphorus oxychloride gases | Semiconductor doping | Specialized - 3674 |
| | Rosin | Soldering flux | General |

Metals - Metals are essential to all electronic components due to their conductive properties toward electricity. Silver, gold, copper, aluminum, tin and their alloys are utilized because their high conductivity is essential to the operation of components or because their use in leads and connectors keeps electric power loss to a minimum. A tremendous variety of alloys of these metals with each other and with other elements such as lead, nickel, chromium, iron, beryllium, zinc, silicon, molybdenum, tungsten, manganese, palladium, and rhodium. These metals or their alloys are selected for use in electronic components according to their conductivity, resistivity, resistance to corrosion, durability transparency to magnetism, transparency to radiation, ease of attachment to other metals and cost.

Another group of alloys including stainless steel, Kovar steel, brass, bronze and phosphorus bronze are selected for use as structural elements of electronic components based upon their strength, ease of attachment to other metals, and conductivity.

Two metals which have poor conductivity in their pure form, silicon and germanium, were used in the surveyed semiconductor plants as substances for integrated circuits and semiconductors. These metals acquire useful electronic characteristics when doped with impurities such as aluminum, boron, phosphorus and arsenic.

With the exceptions of beryllium metal and beryllium/copper alloy (.4 to 2.0% Be), the metals in this material category have no hazardous properties. Small surface to volume ratios of metal and metal scrap prevent significant dissolution in water and solvents. Some possibly hazardous metal oxides and metal ions may be lost to wastewater streams as a result of metal cleaning operations using acids, alkalies or cyanides. Metal ions and oxides so generated will, however, be treated and disposed of along with similar ions and oxides from other material categories.

Metal Salts - The predominant use in the electronic components industry of non-carbonate metal salts is in electroplating. Many metal parts used in components must be protected from corrosion by plating with nickel, chromium, silver, gold, rhodium, or tin. Typically, steel or copper parts must be plated with copper prior to the protective metal plating. Combinations of the plated metals, either in layers or as alloys with each other or with additional metals such as indium, zinc, cadmium, or cobalt are also used.

A list of metal plating processes which were recognized during the plant survey or which would probably find application in the industry is presented in Table III-6. Also shown in that table are the components of the plating baths which might have to be removed from dragout wastewater or which would be present in the concentrated baths when disposed of. Concentrations in ounces per gallon and grains per liter shown are for fresh baths. Concentrations in the depleted baths may be equal to or somewhat less than in the fresh bath, since optimum plating characteristics are not maintained below the minimum concentrations shown. Constituent concentrations in dragout wastewater will be several orders of magnitude less than the bath concentrations because of dilution.

## TABLE III-6

### Metal Plating Processes, Bath Constituents and Concentrations of Constituents in the Electronic Components Industry

| | | Operating Concentrations | |
|---|---|---|---|
| Plating Process | Main Bath Constituents | (oz/gal.) | grams/liter |
| Cyanide Copper (alkaline) | $Cu^{++}$ | 2-11 | 15-82 |
| | Free $CN^-$ | .5 - 2.4 | 3.7-18 |
| Copper Pyrophosphate (alkaline) | $Cu^{++}$ | 2-4 | 15-30 |
| | pyrophosphate | 23 - 28 | 172-209 |
| Copper Sulfate | $Cu^{++}$ | 5.2 - 6.6 | 39-49 |
| | sulfuric acid | 4 - 10 | 30-75 |
| Copper Flurborate | $Cu^{++}$ | 8 - 16 | 59-118 |
| | $BF^-$ | 22 - 44 | 164-329 |
| Watts Nickel | $Ni^+$ | 7.7 - 14.2 | 58-106 |
| | sulfates and chlorides | not specified | |
| | Boric acid | 4 - 6 | 30-45 |
| Sulfumate Nickel | $Ni^+$ | 8.2 - 15 | 61-112 |
| | Sulfamate ($SO_3NH_2$) | 26 - 15 | 194-860 |
| | boric acid | 4 - 6 | 30-45 |
| Fluoborate Nickel | $Ni^{++}$ | 7.6 - 10.5 | 57-78 |
| | $BF_4^-$ | 22 - 30 | 164-224 |
| | boric acid | 2 - 4 | 15-30 |
| Bright Nickel | same as Watt's Nickel with cobalt, zinc, cadmium or organic brightners | | |
| Electroless Nickel | $Ni^{++}$ | 6 - 13 | 45-97 |
| | Sodium hypophosphite | 10 - 27 | 75-202 |
| Decorative chromium | $Cr\,O_3$ | 20 - 54 | 150-404 |
| Silver | $Ag^+$ | 2.6 - 3.5 | 19-26 |
| | Free $CN^-$ | 4 - 6 | 30-45 |
| Gold | Au | .16 - 2.5 | 1.2-19 |
| | Free $CN^-$ | 4 - 6 | 30-45 |
| Rhodium | Rh | 1.3 - 2.6 | 9.7-19 |
| Tin | Sn | 5 - 21 | 37-157 |

SOURCE: Metals Handbook, Vol. 2 [26].

Metals to be electroplated must be thoroughly cleaned. A cyanide copper plate is often the first layer applied. Immediately before this is done, a cyanide cleaning bath containing either potassium or sodium cyanide is used. These salts are also added to copper, silver and gold plating baths themselves to maintain the design concentration of cyanide.

A second significant use of metal salts in the electronic component industry is as luminescent phosphors in cathode ray tubes. Phosphors are crystalline salts, usually sulfides, silicates or fluorides to which a small amount of metal has been added as an impurity. Average size of the phosphor particles usually lies between 2 and 20 micrometers. The phosphors luminesce with color and emission persistence characteristics that depend on the composition of the phosphor, particle size, thickness of the glass screen, and phosphor application technique [27].

A list of registered phosphors is presented in Table III-7 along with their typical uses. Phosphors P4 and P22 are expected to be the most widely used due to their application in television picture tubes.

A specialized use is made of zinc stearate, an organic salt, for binding powders in non-plastics molding operations. Zinc stearate is blended with mixtures of metal oxides or other compounds prior to molding components or component parts. Baking volatilizes the stearate and binds the particles into a solid mass. Use of zinc stearate was recognized during the plant surveys in the manufacture of resistors and ferrites.

A specialized use of ammonium dichromate is made in screening color television picture tubes. Photoresist used to form a matrix on the screen contains this toxic salt. When selectively stripped from the screen with hydrogen peroxide, the photoresist and dichromate salt are removed from the tube and disposed of.

Metal Oxides and Carbonates - A variety of purposes were found during the plant surveys for metal oxides and carbonates in the electronic components industry.

Metal carbonates were found to be components of ferrite materials and permanent magnets. Magnesium, ammonium, calcium and nickel carbonates are powdered and mixed with the oxides of iron, zinc, magnesium, lead and strontium prior to molding into various shaped ferrites. Barium, strontium, and calcium carbonate are coated on the cathodes of electron tubes, both receiving and cathode ray tubes.

Lead oxides are used in the finishing and repair of glass tubes. The oxide is a major component of glass stock used to make glass to glass seals (glass fritting) when inserting cathode ray guns in TV picture tubes, for instance.

Cadmium oxide is the source of cadmium in electroplating. Only limited use of cadmium plating was recognized in plant visits. Cadmium plate protects steel parts by sacrificial corrosion. Cadmium's solderability and the small amount of corrosion products it generates make cadmium attractive in

## TABLE III-7

## COMPOSITION OF CATHODE RAY TUBE PHOSPHORS [27]

| PHOSPHOR | COMPOSITION | MAJOR USE |
|---|---|---|
| P1 | Zinc silicate: manganese | Cathode ray oscillography and radar |
| P2 | Zinc sulfide: copper | Cathode ray oscillography |
| P3 | Zinc beryllium silicate: manganese | Not provided |
| P4 | Zinc sulfide: silver and Zinc cadmium sulfide: silver | Black and white TV tubes |
| P5 | Calcium tungstate | Photographic application |
| P7 | Zinc sulfide: silver and Zinc cadmium sulfide: copper | Radar and oscillography |
| P9 | Calcium pyrophosphate | Not provided |
| P10 | Potassium chloride | Traffic control radar |
| P11 | Zinc sulfide: silver | Photographic applications |
| P12 | Zinc magnesium fluoride: manganese | Radar |
| P13 | Magnesium silicate: manganese | Not provided |
| P15 | Zinc oxide | Flying spot scanning systems & photographic applications |
| P16 | Calcium magnesium silicate: cerium | Flying spot scanning systems & photographic applications |
| P17 | Zinc oxide and Zinc cadmium sulfide: copper | Not provided |
| P18 | Calcium magnesium silicate: titanium and Calcium beryllium silicate: manganese | Not provided |
| P19 | Potassium magnesium fluoride: manganese | Radar |
| P20 | Zinc cadmium sulfide: silver | Yellow component of P4 |
| P21 | Magnesium fluoride: manganese | Radar |
| P22 | Zinc sulfide: silver, Zinc silicate: manganese, Zinc phosphate: manganese | Color TV tubes |
| | Zinc sulfide: silver, Zinc cadmium sulfide: silver, Zinc cadmium sulfide: silver | Color TV tubes |
| | Zinc sulfide: silver, Zinc cadmium sulfide: silver, Yttrium vanadate: europium | Color TV tubes |
| | Zinc sulfide: silver, Zinc cadmium sulfide: silver, Yttrium oxysulfide: europium | Color TV tubes |
| | Zinc sulfide: silver, Zinc cadmium sulfide: copper, Yttrium oxide: europium | Color TV tubes |
| | Zinc sulfide: silver, Zinc cadmium sulfide: copper, Yttrium oxysulfide: europium | Color TV tubes |
| P24 | Zinc oxide | Flying spot scanner tubes |
| P25 | Calcium silicate: lead: manganese | Slow luminescence decay tubes |
| P27 | Zinc phosphate: manganese | Color TV monitor service |
| P28 | Zinc cadmium sulfide: copper | Radar |
| P31 | Zinc sulfide: copper | Oscilloscope tube |
| P32 | Calcium magnesium silicate: titanium, Zinc cadmium sulfide: copper | Radar |
| P33 | Magnesium fluoride: manganese | Radar |
| P34 | Zinc sulfide: lead: copper | Oscillography, radar - slow luminescence decay |
| P35 | Zinc sulfide selenide: silver | Oscillography |
| P36 | Zinc cadmium sulfide: silver: nickel | Flying spot scanning |
| P37 | Zinc sulfide: silver: nickel | Flying spot scanning and photographic application |
| P38 | Zinc magnesium fluoride: manganese | Radar |
| P39 | Zinc silicate: manganese: arsenic | Radar |
| P40 | Zinc sulfide: silver<br>Zinc cadmium sulfide: copper | Slow luminescense decay - similar to P4 |
| P41 | Zinc magnesium fluoride: manganese<br>Calcium magnesium silicate: cerium | Mix of P12 and P16 |

electronic components where electric current flow must not be impeded and parts are required to fit to small tolerances. Cadmium plate cannot be used on external surfaces of components that heat up because toxic cadmium fumes may be generated [26]. Handling and disposal of cadmium oxide is likewise critical.

Yttrium oxide is a component of at least one phosphor used for color television picture tubes. No toxicity hazard has been determined for yttrium oxide.

Titanium oxide is used in formulating powder mixtures molded into carbon core resistors. Toxicity of titanium oxide is very low and presents no known hazard [20]. Sand, chiefly silicon oxide, is also used for compounding the resistor mixtures.

Aluminum oxide finds several applications in the electronic components industry. Sapphire and ruby crystals used as solid state device substrates and laser crystals are aluminum oxide containing metal impurities. Aluminum oxide is used for grit blasting of metal and glass parts and, in finely ground powders, for grinding and polishing metals and non-metals. Also, minor use is made of aluminum oxide in coating semiconductor products. Aluminum oxide has no hazardous properties.

Other metal oxides used in the industry can be generally classified as dielectric ceramics and subclassified as electrical insulators or piezoelectric ceramics. Ceramic electrical insulators are generally made of porcelain which presents no hazard. However, in electron tubes where high temperatures are expected, beryllium oxide ceramic is used. Cutting and grinding of the beryllium oxide ceramic produces powder which can cause skin irritation and respiratory damage [20].

Piezoelectric ceramics or crystals possess electrical properties due to their not having identical centers of positive and negative charges in their crystal structures. Mechanical compression or elongation of these materials produce weak electric impulses so that pressure applied to piezoelectric ceramics can be determined by measuring voltage potential across them. Alternatively, electrical signals applied to the ceramics produce movement which can be used to produce high-frequency sound waves and to tune electronic circuits [28]. With the possible exception of lead zirconium oxide, which was not found in the plant surveys, the piezoelectric ceramics are chemically inert and would not present a handling or disposal hazard. Piezoelectric ceramics found during the plant surveys were barium titanate and silicon dioxide (quartz).

Glass - Glass finds its most general use in the electronic components industry as a structural element in television picture tubes and electron ray tubes. Many special purpose glasses are developed for such uses as windows in special purpose electronic tubes and as photoconductors, a subcategory of semiconductors.

Although some heavy metals are added to glass, the chemical structure of glass is such that no hazard, aside from physical injury by broken glass, is likely.

Plastics - The most common use of plastics in the electronic components industry is for encapsulation of individual components. Thermoplastic, thermosetting and epoxy polymers are utilized for this purpose. Thermoplastic polymers, including acetyls, acrylics, nylons, polystyrenes and cellulosics, and thermosetting polymers, including aklyds, aminos, epoxies, phenolics, and polyesters, are applied to small components by injection or transfer molding. Thermal setting silicon/rubber formulations are normally used for making seals on large components. Other components, due to irregular shape sensitivity to temperature or large size, must be encapsulated by casting methods which normally employ two-part epoxy resins. A special use of two-part epoxy resins is made when the plastic must have electrical conducting properties. For this purpose, high concentrations of finely powdered silver is a part of the resin. Cast plastics harden as a result of chemical polymerization instead of temperature-dependent polymerization.

With the exception of some possible migration of minor amounts of plasticizers, none of the plastic materials used are considered hazardous. Incineration of plastics is to be avoided because of the release of toxic gases from some types of plastics.

Paints and Organic Coatings - Many electronic components are spray painted, dip coated and/or printed with an identification label. Solvent thinned paints or coatings are generally used for components due to the extra measure of protection they afford in humid environments compared to water-based paints. Enamels and epoxy-based paints were found during the plant surveys to be hand sprayed on components in dry air filter spray booths. Components requiring maximum protection from humidity but which cannot be electroplated, such as filter coils, rheostate and transformer coils, are dipped in lacquers or varnishes. These organic coatings are mixed with a high proportion, up to ninety-six percent, of solvents such as xylene. Complex components such as assembled circuit board modules may also receive an organic coating either as the final protective measure or prior to casting in plastic. Acrylic paints find use in printing and labeling operations. Also, an acrylic lacquer is used with a toluene carrier to coat the inside of aluminized-screen television picture tubes with powdered aluminum.

Paints containing heavy-metal pigments could present a hazard if improperly handled. Thinning solvents have various flash points and toxicities as vapor but might generally be considered hazardous. Labor regulations require adequate ventilation in painting and dipping areas so that in-plant hazards are minimized.

Specialized uses of graphite-containing paint and of polychlorinated biphenyls were recognized during the plant surveys. Graphite-containing paints are used as a conductive film on the inside of television picture tubes. These paints are sprayed on in the manner of other oil and epoxy based paints but use polyvinyl alcohol as the vehicle. No additional hazard is imparted to the paints by the addition of graphite. Polychlorinated biphenyls were used in one surveyed plant as an organic coating on carbon-core resistors. The polychlorinated biphenyls impregnate the composition material and, when dry, waterproof the resistor. The use of these highly toxic compounds for this purpose is being discontinued in the surveyed plant. The material chosen to replace PCB's in this application was not reported.

Oils - With the exception of zero-sulfur oil used for filling a special purpose electron tube, oil uses recognized during plant surveys were related to product fabricating operations. Oils are generally not incorporated into the products themselves.

Cutting oils are mixed with water and used as coolants and lubricants in metal and non-metal cutting, grinding and polishing operations. The oil itself is often a petroleum distillate that may contain additives such as organic stabilizers, bactericides, corrosion and foaming inhibitors, dyes, and inorganic water conditioners. The water soluble cutting oils are mixed with water so that the oils compose from 2 to 20 percent of the coolant. The mixture is typically a fine emulsion, not a true solution. Although some cutting oil additives may be toxic or have detrimental properties if distributed in the environment, it is beyond the scope of this report to survey these additives.

Mineral oil, also a petroleum distillate, is used undiluted as lubricants and coolants for the same purposes as cutting oils. Although mineral oils are recognized as carcinogens of the skin and scrotum [20], they are also used medicinally as a laxative.

Minor amounts of hydraulic oil are used to replace leaked or discarded oil in metal and non-metal forming machines and in plastics molding machinery. Hydraulic oils are refined from lube oil stock and have had solvents and waxes extracted. As with cutting oils, various additives are present in hydraulic oils depending upon their industrial application.

Halogenated Solvents - The electronic properties of many materials used in manufacturing electronic components depend on the absence of unwanted impurities. Most components are, therefore, cleaned at one or more points in their process flow scheme. The most commonly used cleaning materials in electronic components manufacturing are the halogenated solvents; trichloroethylene, 1,1,1 trichloroethane, perchloroethylene and trifluorotrichloroethane. These solvents are excellent degreasers. They can be used in both vapor and immersion degreasers. Vapor degreasing is used where cleanliness standards are especially high since the vapors stay cleaner than solvents in which parts are immersed.

Trichloroethylene is gradually being replaced by the less reactive 1,1,1 trichloroethane. Trichloroethylene is one of the solvents controlled by Rule 66 of the Los Angeles Air Pollution Control District as being photochemically reactive [29]. Recognition of this property resulted in the development of 1,1,1 trichloroethane as a less reactive substitute in cleaning operations.

Specialized use is made of trichloroethylene in testing the operation of some components at low temperatures. Since it does not freeze above -86.8°C (-124°F), trichloroethylene is used in low temperature baths for testing component performance at low temperatures.

Trifluorotrichloroethane, also known as Freon, is most commonly used in vapor degreasing equipment. Some use of this solvent is made in soaking or wiping applications, but its low boiling point, 118°F, and low latent heat of vaporization make the solvent economical to heat to its vapor point, offsetting initial high cost of the solvent itself. Trifluorotrichloroethylene does not attack some varnishes and paints that the other solvents would soften and dissolve.

Perchloroethylene can be used interchangeably with the other halogenated solvents for some applications. In vapor degreasing, it is used in preference to the other halogenated solvents where high operating temperatures are desirable. Its boiling point is the highest of this group, 250°F.

Methylene chloride use was found to be more restricted in the electronic components industry than the other halogenated solvents. It is sometimes mixed with trifluorotrichloroethane in vapor degreasers. It was also found to be used in removing paint and in softening resins during reclamation of defective television picture tubes.

The halogenated solvents are of primary importance in cleaning electronic components because of their excellent abilities to solubilize waxes and greases. Their lack of flash points [18] make them safer than most non-chlorinated solvents from the aspect of fire hazards. These solvents are volatile, however, and the vapors can be narcotic and toxic. Excessive inhalation of the vapors can cause headaches, fatigue, loss of appetite, nausea, coughing and a loss of the sense of balance [20]. Threshold limit concentrations in air for constant exposure without harm range from 100 parts per million for trichloroethylene and perchloroethylene to 1000 parts per million for trifluorotrichloroethane [30]. Adequate ventilation in work and storage areas is, therefore, required.

An additional hazard is posed when these solvents are oxidized by high intensity light or exposure to temperatures of 250°F up. The by-products of dichloroacetyl chloride, phosgene and hydrochloric acid [20].

Hazards related to halogenated solvent use in industrial applications have been adequately documented. However, hazards to the environment are not clearly defined for these solvents except for the photochemical reactivity of trichloroethylene. The halogenated solvents used in electronic components manufacture are members of a group of compounds, chlorinated hydrocarbons, which includes many persistent and toxic materials that have severe environmental consequences when improperly distributed or disposed.

Non-chlorinated Solvents - The properties of non-chlorinated solvents vary greatly and are, therefore, utilized for a variety of applications in the electronics components industry. Twelve different non-chlorinated solvents were used in surveyed plants and as many specific applications were recognized. General types of applications for these solvents are immersion degreasing and drying; thinners for paints and lacquers; vehicles for photoresists, paints and polishing compounds; photoresist developing and cleanup of painting and other equipment.

All of the non-chlorinated solvents used in the surveyed plants are toxic to some degree if ingested or inhaled for long periods of time, above certain threshold concentrations. However, their most significant hazardous property as a group is their flammability. The various solvents, their flash points and threshold concentrations are listed in Table III-8.

Acids and Alkalies - Precleaning of metals as part of electroplating operations, etching of silicon in semiconductor manufacture, addition of boric acid in nickel plating baths and removal of surface impurities from some non-metals require the use of acids and/or alkalies. Sodium hydroxide was the only alkali found in surveyed plants. A sodium hydroxide bath commonly follows acid rinse baths in electroplating shops. Strong sodium hydroxide solutions are markedly corrosive to skin.

Hydrochloric, hydrofluoric, nitric, sulfuric, acetic, boric, and phosphoric acids are used in the processes noted above. As with sodium hydroxide, the corrosive nature of these acids requires care in handling.

Etching of silicon dioxide from silicon and glass component parts is normally accomplished with concentrated solutions of hydrofluoric acid. Fluoride ions in the concentrated waste acid and in rinse waters are present in high concentrations in the wastewaters of plants etching silicon or glass. Fluoride is an acceptable constituent in water in concentrations of 1.4 to 2.4 mg/l because of the protection it provides in preventing dental caries [13]. However, excessive concentrations of fluoride ions causes dental fluorosis and, in human body doses on the order of 2.5 grams, death [20]. Reduction of wastewater fluoride concentrations is required by state regulations in at least one of the plants surveyed for this report.

Miscellaneous Raw Materials - Several materials were used in surveyed plants which do not readily fit into the above categories. Their use and hazardous nature are discussed separately here.

Graphite - Conductive paints containing finely ground graphite are used in television picture tubes to help disperse excess ionic energy from the screen phosphors. Ground graphite is also a component of the carbon core in composition resistors. In neither case is graphite considered hazardous.

Carbon - Like graphite, powdered carbon is a component of the carbon core in composition resistors. Also like graphite, it is not considered hazardous.

## TABLE III-8

## Non-Chlorinated Solvents Used in Surveyed Plants, Their Flash Points and Threshold Limit Values

| | Flash Point °F (1) | Threshold Limit Value (TLV) ppm (2) |
|---|---|---|
| Methyl Alcohol | 50 | 200 (3) |
| Isopropyl Alcohol | 53 | 400 (3) |
| Polyvinyl Alcohol | 175 | None |
| Ethyl Acetate | 24 | 400 |
| N-Butyl Acetate | 72 | 150 |
| Xylene | 84 - 115 | 100 (3) |
| Acetone | 0 | 1000 (3) |
| Methy Ethyl Ketone (2-butanone) | 22 | 200 |
| Cyclohexanone | 111 | 50 |
| Stoddard Solvent | 100 - 110 | 100 |
| Phenolic Developer | | (composition not known) |

(1) SOURCE: Dangerous Properties of Industrial Materials, Sax, N.I. [20].

(2) From: "Threshold Limit Values for Chemical Substances in Workroom Air Adopted by the American Conference of Governmental Industrial Hygienists for 1974" reprinted in Sax [20].

(3) Solvents that can be absorbed continuously from airborn concentrations or by direct contact. Overall exposure can be thereby increased as well as direct effects such as mucous membrane irritation, corneal burns or skin defatting.

Silicon carbide - Carborundum is used to grind quartz crystals to desired shape and thickness. The carborundum by itself is inert and poses no hazard.

Asbestos mat - Expensive, fragile glass parts and other component parts are wrapped in matted asbestor fiber for shipping. Although chemically inert, long exposure to asbestor fibers in the atmosphere can lead to pulmonary fibrosis. While any use of asbestos might increase ambient levels, this use is not prevalent enough to be of specific concern in the electronic components industry.

Arsine, dioborane, phosphine and phosphorus oxychloride gases - Concentrations of these highly toxic gases in the parts per million range are used in controlled temperature furnaces to dope exposed surfaces on silicon wafers being made into integrated circuits. These gases, whether as exhaust from furnaces, as escaped gases from cylinders, or as remnants in used cylinders, pose serious industrial hazards. Therefore, common practice is to vent furnace exhausts and closed cylinder encasements to water scrubbers or directly to the atmosphere. Minute quantities of arsenic from arsine will be sorbed on the photoresist and exposed silicon surfaces and, hence, would end up in waste photoresist solvents and in scrap silicon. This quantity is expected to be too low to be of concern in land disposed wastes.

Rosin - Rosin is used as soldering flux in soldering operations. Rosin applied to wire connections cleans the oxides from the metal when heated. This is necessary to assure a good mechanical and electrical connection between wires and the solder. Rosin is not toxic although it may act as an allergen. Its flash point is necessarily high, 370°F, so that it does not ignite when solder is applied with heat.

## Manufacturing Processes and Process Wastes

Based upon information gathered in twenty-two plant surveys, there are no manufacturing processes in general use throughout the electronic components industry. Product and process designs are tremendously varied. These design differences result in component cost and performance differences which determine the competitive position of manufactures in a very competitive market. Continuing improvements in product and process design technology assure that this situation will not change in the direction of design standardization.

Forty manufacturing processes were recognized in the twenty-two plants surveyed. These manufacturing processes can be grouped into eight process categories. With the exception of Solvent Cleaning and Drying, process categories used here are the same as those used in "Development Document for Effluent Limitation Guidelines and Standards of Performance for the Machinery and Mechanical Products Manufacturing Point Source Category" [7]. Solvent Cleaning and Drying is included here as a separate process category because of its frequency of occurrence and because solvent wastes are identifiable in almost all instances as a waste stream that is segregated from other process wastes. It is interesting to note that all of the process categories found in machinery and mechanical products manufacturing except casting and molding metals and smelting and refining are found in electronic components manufacturing.

The occurrence of the manufacturing processes by product classifications is summarized in Table III-9. The only manufacturing process that was used in more than one-half of the plants was solvent cleaning. Eight other processes were used in more than one-quarter of the plants: sawing and cutoff, baking, electroplating, acid cleaning and etching, dry booth painting, vacuum metalizing, thermoforming plastics, and casting plastics. Process descriptions and their typical process wastes are described for these nine most frequently encountered manufacturing processes.

Solvent cleaning - The requirement for frequent, high efficiency cleaning of raw materials and partially manufactured components is related to the impact of impurities on component performance. Often, where a range of solvents and solvent cleaning equipment is available, the more expensive alternative is chosen if it improves cleaning efficiency. For this reason the halogenated solvents are used extensively in electronic components manufacturing. While they are generally more expensive than non-halogenated solvents, they are also more effective for many purposes.

Three basic solvent cleaning operations were recognized in the surveyed plants: manual cleaning, immersion, and vapor degreasing. Manual cleaning with solvents is typically used on process equipment such as spray painting guns, organic coating vats, vacuum metalizing domes, and polishing and lapping machinery. Because the residuals to be removed are often heavy organics, light solvents such as acetone and Stoddards solvent are used. Rags and scraping equipment must be used also. Wastes from manual cleaning with solvents are normally too dirty or are mixed with rags so that solvent recovery is impractical. The wastes are, with notable exceptions, small in quantity and are disposed of along with paper and container wastes in dumpsters. One exception is found in magnetic tape manufacturing where batch mixing wastes are manually cleaned from process equipment. The quality of waste from this operation can be significant. Metal oxides, vehicle solvent for dip coting, and the clean-up solvent would be included in the solvent wastes from manual cleaning.

Immersion of raw materials, partially manufactured components and components to be reworked or repaired in solvents is standard practice when high-efficiency cleaning is not required. Immersion baths become more and more contaminated with use until they must finally be discarded. Since cleanliness standards are generally high, waste solvents from immersion baths are capable of being reclaimed with a high percentage of solvent yield. Any of the cleaning solvents described in Raw Materials can be used in immersion baths. These include all of the halogenated solvents, methanol, isopropyl alcohol, acetone, toluene and methy ethyl ketone. Methanol and acetone immersion baths can serve the additional purpose of removing water from materials after other types of cleaning that involve acids and water. In some cases the methanol and acetone wastes require only dewatering to be reusable. Mechanical agitation of component parts in solvent baths or ultrasonic agitation of solvent and parts is practiced in many cases.

Whereas immersion cleaning is commonly done at room temperature, vapor degreasing requires heating of solvents to their boiling point. For this reason, the halogenated solvents must be used to reduce fire hazard. The

## TABLE III-9

### MANUFACTURING PROCESSES USED IN SURVEYED ELECTRONIC COMPONENTS PLANTS

| PROCESS | 3671 | 3673 | 3674 | 3675 | 3676 | 3677 | 3678 | 3679<br>Crystals | 3679<br>Passive Components | 3679<br>Ferrites | 3679<br>Magnetic Tape | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER OF PLANTS SURVEYED | 2 | 3 | 5 | 1 | 2 | 2 | 1 | 2 | 4 | 1 | 2 | 27 |
| Mechanical Material Removal | | | | | | | | | | | | |
| Sawing and cutoff | 2 | 2 | | 1 | | | 1 | 2 | | | | 8 |
| Grinding, polishing or lapping | | | 1 | | | | | 2 | | 1 | | 4 |
| Scribing | | | 4 | | | | | | | | | 4 |
| Grit Blast | 1 | | 1 | | | | | | | | | 2 |
| Mechanical Etching | | | 1 | | 1 | | | | | | | 2 |
| Material Forming | | | | | | | | | | | | |
| Metal forming | 1 | | 2 | | | | | | 1 | | | 4 |
| Glass forming | | 1 | | | | | | | | | | 1 |
| Non-plastic molding | | | | 1 | 1 | | | | | 1 | | 3 |
| Physical Property Modification | | | | | | | | | | | | |
| Baking | 2 | 2 | | 1 | 2 | | | | | 1 | | 8 |
| Milling | | | | 1 | 1 | | | | | 1 | 2 | 5 |
| Doping (Epitaxial deposition) | | | 4 | | | | | 1 | | | | 5 |
| Crystal growth | | | | | | | | 1 | | | | 1 |
| Assembly Operations | | | | | | | | | | | | |
| Hand soldering | | | | | | 1 | | 1 | | | | 2 |
| Wave soldering | | 1 | | 1 | | 1 | | | 1 | | | 4 |
| Furnace soldering | | 1 | 2 | | | | | | | | | 3 |
| Spot welding | | | 2 | | | | | | | | | 2 |
| Gold bonding | | | 1 | | | | | | | | | 1 |
| Brazing | | 3 | | | | | | | | | | 3 |
| Mechanical lead attachment | | | | | 1 | | | | 1 | | | 2 |
| Wire winding | | | | | | 2 | | | | | | 2 |
| Glass/metal seal | | 2 | | | 1 | | | | | | | 3 |
| Glass fritting | 2 | | | | | | | | | | | 2 |
| Chemical-Electrochemical Operations | | | | | | | | | | | | |
| Electroplating | | 3 | 1 | | | | 1 | 1 | | | | 6 |
| Alkaline cleaning of metals | | 3 | | | | | 1 | | | | | 4 |
| Cyanide cleaning of metals | | 3 | | | | | 1 | | | | | 4 |
| Acid cleaning and etching | 1 | 3 | 4 | | | | 1 | 1 | | | | 10 |
| Electroless plating | | | 2 | | | | | | | | | 2 |
| Material Coating | | | | | | | | | | | | |
| Dry booth painting | 2 | 2 | 1 | 1 | 1 | 1 | | | 1 | | | 10 |
| Vacuum metalizing | 1 | | 4 | | 1 | | | 1 | 1 | | | 8 |
| Printing/labeling | 2 | 1 | | | | | | | | | | 3 |
| Organic coating (dipping) | | 1 | | | 1 | 1 | | | | | 2 | 5 |
| Photoresist application | 1 | | 5 | | | | | | | | | 6 |
| Gold termination | | | | | 1 | | | | | | | 1 |
| Carbonate salt coating | 1 | | | | | | | | | | | 1 |
| Phosphor deposition | 2 | | | | | | | | | | | 2 |
| Molding and Forming Plastics | | | | | | | | | | | | |
| Thermoforming plastics | | 2 | 3 | 1 | 1 | | 2 | | 1 | | | 10 |
| Casting plastics | 1 | 2 | 1 | | 2 | 1 | | | | | | 7 |
| Solvent Cleaning and Drying | | | | | | | | | | | | |
| Solvent cleaning | 2 | 3 | 4 | | 1 | 1 | 1 | 2 | | 1 | | 15 |
| Solvent drying | | 1 | 3 | | | | | 1 | | | | 5 |

halogenated solvents have no flash point whereas all of the commonly used non-halogenated solvents have flash points within or slightly above plant operating ranges. Vapor degreasing is the most attractive solvent cleaning method where high cleaning efficiency is required. The solvents are heated in the bottom of the vapor degreasing tank. Solvent vapor is condensed and prevented from leaving the degreasing equipment with the use of cooling coils around the top of the bath. At the same time the vapor condenses on the materials lowered into the tank to be cleaned. Solvent vapors contain little or no impurities to be left as a film on the product when it dries. Many vapor degreasers come equipped with solvent distillation equipment or can be easily converted to distill contaminated solvent, thereby increasing the useful life of solvents and reducing wastes. Sludge from solvent distillation, because the quantities produced are generally minor and because impurities are concentrated, is not ameanable to recovery except from very large volume operations.

Sawing and Cutoff - This process designation refers here to any operation where metal or non-metal stock or component parts are altered in size or shape by mechanical means. In crystal manufacturing, the process involves the use of thin grinding wheels operated at high speed to shape the desired part by removing slabs or discs from stock material. For metals, sawing and cutoff is used here to cover a variety of machine shop operations used in metals forming. Only three plants had multiple machine shop operations - two producing parts for special electron tubes, SIC 3673, and one producing parts for electronic connectors, SIC 3678. Glass cutting to remove electron guns from TV picture tubes to be repaired and trimming stacks of metal and ceramic wafers in capacitor manufacture were the other sawing and cutoff type manufacturing processes recognized in the plant surveys.

Wastes from sawing and cutoff depend upon the material involved. A slurry of grinding powder and cutting oil or mineral oil is generated from sawing and cutoff of crystals. The machine shops generate metal scrap often coated with cutting oil. Electron guns are discarded from TV picture tube repair operations. Mixed metal and ceramic scrap from capacitor manufacturing is collected for metal salvage.

The saws, lathes and presses used in sawing and cutoff operations require maintenance. Replacement and leakage of hydraulic oil in some machinery produces a minor amount of this oil as waste. Periodic cleaning of lathes and saws with solvents results in generation of minor amounts of waste solvents generally too contaminated and in too small volume for reclamation.

Baking - Baking is used to set organic binding agents such as zinc stearate and to remove gaseous impurities from metals. Organic binders are used to consoldiate the milled components: capacitors, resistors, and ferrites. Films containing metal salts are bound to picture tube screens by baking off similar binders. Hydrogen impurities in the metal bodies of some special purpose electron tubes are removed by simultaneous baking and vacuum evaluation of the tube body. Baking, as defined by these operations, produces no wastes of concern to this report. Some exhausts may contain ~~gaseous~~ contaminants but none have been turned into wastes that require land disposal.

Other manufacturing processes that could be considered types of baking are doping, crystal growth and furnace soldering. These processes are not included as baking processes in Table III-9. Doping, or expitaxial deposition, is a basic process in producing semiconductors and integrated circuits. Prepared silicon wafers are heated in quartz containers containing an inert gas plus small concentrations of arsine, diborane, phosphine, phosphorus oxychloride or silane gas. The dopant gas diffuses into exposed surfaces of the wafer. The impurities determine the electronic character of the silicon surface. While the dopant gases are all highly toxic, it appears to be unlikely that they would end up in detectable quantities in any wastes disposed of on land.

Sapphire and ruby crystals are grown by slowly cooling molten aluminum oxide as it is being drawn out of a molten bath. Lumps of aluminum oxide left in the crucibles is the only waste from this process.

Furnace soldering uses the same material as wave or hand soldering, a tin/lead alloy, but performed pieces of solder are clamped in place on component parts and are fused in place inside furnaces. There is no waste from this process. All solder normally adheres to the component.

If the plants using baking, as defined for Table III-9, are added to the other plants using similar furnacing operations, then these operations would be as common in the surveyed plants as solvent cleaning. However, there is very little material waste generated by the operations and none of it would be considered hazardous.

Acid Cleaning and Etching - Acid solutions are used in electronic components manufacturing to clean surface impurities from non-metals such as glass and aluminum oxide, to clean metals prior to electroplating, to etch silicon oxide from silicon wafers used in semiconductors and to soften various organic films.

Hydrofluoric acid is used extensively in the industry for glass cleaning and silicon etching in semiconductor manufacturing due to its ability to remove silicon oxide. Hydrochloric, nitric and sulfuric acids are commonly used to clean metals prior to electroplating. A mixture of sulfuric acid and hydrogen peroxide is used to remove photoresists from silicon wafers in integrated circuit production.

The cleaning or etching is a simple process in which parts are first immersed in appropriate concentrations of acid and then rinsed in water.

The acid necessarily dissolves some of the material being cleaned. This becomes significant in cleaning of metals since the waste acids will contain some of the metals as particles or as ions. Neutralization of the acid baths and the rinse waters is commonly practiced but this does not necessarily remove the metals. Where chemical precipitation is employed to remove metals, they are incorporated into the treatment sludge.

Electroplating - Electroplating is a process in which an adherent metallic coating is deposited on an electrode (the part being plated) to produce a surface with properties or dimensions different from those of the basic metal. In the electronic components industry the purpose of electroplating is most frequently to provide corrosion resistance to metal component parts. Exceptions to this include the electroplating of silver on quartz crystals to provide the exact dimensions necessary for tuning the crystal and electroplating silicon wafers with layers of gold and silver to produce zehner diodes.

Salts of the metal to be plated on the component part are dissolved in the aqueous electroplating bath. Metals used and composition of the baths has been discussed in Raw Materials and are listed in Table III-6.

Wastes from spent or contaminated baths and from rinse waters are all carried and have little solids content. Traditionally, therefore, much of these wastes have been discharged directly to municipal sewers. However, the toxicity of metal ions and cyanides in these wastes and modern efforts to properly treat and dispose of them is resulting in increasing use of chemical precipitation to remove the metals. Where cyanide is also discharged it is oxidized prior to chemical precipitation for metals removal.

Dry Booth Painting - Many component parts and finished components are painted for decoration and/or corrosion protection. Painting may be either an alternate or a supplement to electroplating for these purposes.

The most frequently recognized method of painting in the plant surveys was dry booth painting. The part, component, or racks of the items are set in a chamber, open on one side and ventilated through the top and/or back, and sprayed by means of air-pressure operated paint guns. Ventilating fans bring air from the work room into the chamber and through air filters. Paint particles which are picked up by the air draft are caught on the air filter and dry there. Clogged air filters and clean-up materials from maintaining the spray guns are the wastes from this type of operation which would be land disposed. In most instances these wastes are included with other plant trash in dumpsters.

Vacuum Metalizing - Thin metal films are applied as conductive elements in several types of components by vacuum metalizing. Depending upon application, aluminum, nickel, chromium, silver or gold are deposited by this technique.

The process involves explosive heating of the metal to be deposited inside a vacuum chamber containing the component parts to be treated. Either electricity passed through a high resistance conductor or radio frequency energy are used to rapidly vaporize the deposition metal. Components are held on racks and oriented toward the metal source.

Wastes from this process are generated when the vacuum dome and racks are cleaned after numerous layers of the metal have been deposited on them. The amount of metal involved is very small since each deposition is very thin. Wire brushes in conjunction with some type of solvent are used manually to clean the domes. When silver or gold are removed, the wastes are generally combined with other precious metal wastes for reclamation. Otherwise, the solvent is disposed of in the same manner as similar solvents used in the plant.

Thermoforming Plastics - This designation for plastics molding includes three similar processes: injection molding, transfer molding and silastic molding. All three processes utilize heat to liquify and/or to polymerize the plastic stock. Injection modling can employ both thermosetting and thermoplastic resins. Scrap from the thermoplastic resins can be reground and used again if mixed with fresh resin. Transfer molding is limited to thermosetting resins which cannot be reused.

Whereas injection and transfer molding are generally used for encapsulation of small components, silastic molding is typically used for forming seals on larger components. The stock material has silicon and rubber constituents which are temperature setting.

Excess plastic material is cut from the component. This scrap constitutes the waste from thermoforming of plastics.

Casting Plastics - Two-part epoxy resins, which polymerize chemically instead of thermally, are used for encapsulation, adhesion and sealing. Application of these resins without the use of heat is termed casting. After mixing, the liquid or semisolid plastic is poured, painted or simply spread on the component or component-part. A special purpose, two-part epoxy resin containing silver powder and used for adhesion or sealing purposes also acts as an electrical conductor.

Unused portions of batches are the waste from casting of plastics. This material hardens and, with the exception of the silver-containing resins, is discarded with the plant trash in dumpsters. The silver-containing resin wastes are typically returned to the supplier for credit on the silver.

In addition to these relatively common processes, five other processes are significant in the amount or type of waste generated.

Grinding, polishing and lapping - These operations are carried out for the purpose of putting a smooth finish on non-metals. Ferrites, crystals and some semiconductor substrates are finished in this manner. These finishing operations involve the use of an oil or solvent vehicle containing an abrasive such as alumina, carborundum or diamond dust. Depending on the coarseness of the abrasive, the process of finishing the material surface is termed grinding (coarse), polishing or lapping (fine).

After finishing or between use of successively fine abrasives, the material being finished is cleaned with solvents. The solvent waste containing the waste abrasive and vehicle constitutes the waste from these processes. Any of a number of halogenated and non-halogenated solvents are used for the cleaning operation. With the exception of finishing ferrites, which contain metal oxides and carbonates, the hazardous properties of the finishing wastes in surveyed plants were related to the type of solvents and oils used as the abrasive carrier or cleaning solvent.

Non-plastic molding - The term "non-plastic molding" is used here to encompass three operations used in surveyed plants which involved molding or extruding composition materials into component parts. The primary similarities between the three processes were that the starting material was first milled to powder form, that a binder was mixed with the powder and that the formed part was baked to set the binder.

However, the starting materials, and therefore, the scrap generated differed in all three cases. One of the wastes was off-spec ceramic material which posed no obvious hazard. Another was a mixture of molded sand, carbon, graphite and organic resins from resistor manufacturing. Some of this material had been soaked in polychlorinated biphenyls and so is considered hazardous. The metal oxides and carbonates that are filter pressed into the approximate size and shape desired for ferrites also appear in the wastewater from the process. Treatment of that wastewater produces a metal-containing sludge for land disposal.

Frit salvaging - In the reclamation of used or improperly made television picture tubes, lead-containing frit solder glass is removed from the tubes with nitric acid. Lead in the wastewater generated by this process is precipitated as lead carbonate by the addition of sodium carbonate. This waste is generated in SIC 3672 and possibly 3671. Despite its restricted occurrence by product area, the high concentrations of lead suspected in the sludge make it a significant waste.

Phosphor deposition - Also limited to occurrence in SIC 3672 is the process of depositing phosphors on television picture tube screens. The composition of phosphors is described in Raw Materials of this report section. The phosphors are mixed with a bonding agent in water and coated on the inside of the tube screen by contact. Approximately one to two percent of the phosphors are lost to the wastewater stream. Some of this can be reclaimed by use of a filter press since the salts are in relatively insoluble, crystalline form. Fine particles are lost to the sewerage system where they can end up as part of a chemical treatment sludge or be discharged to municipal sewers. Zinc and cadmium in these water carried wastes are of concern due to their toxicity to wildlife and humans [14].

Cyanide cleaning of metals - Prior to electroplating with copper, the part to be plated must be precleaned in an alkaline cyanide solution. Both the concentrated cyanide bath and the rinse water used to remove the cyanide must be disposed of. With one exception in the plant survey, both the baths and rinse waters are treated by alkaline chlorine oxidation of the cyanide thereby lowering the cyanide concentrations to acceptable levels. This treatment is performed prior to mixing with any other wastewaters to avoid the possibility of releasing hydrogen cyanide by acidifying the wastes. Neither remaining cyanide nor the much less toxic intermediate oxidation product, cyanate, would be found in higher concentration in the wastewater treatment sludges than in treated wastewater. For this reason cyanides are not a hazardous component of wastewater treatment sludges.

One of the four plants which used the cyanide cleaning process and had electroplating baths containing cyanides disposed of the spent or contaminated baths by drumming and burial in a secured landfill. This is being done in spite of the fact that equipment for oxidation of dilute cyanide rinse waters is, or will be provided. The availability of a secured landfill and a contractor to haul the wastes, plus the economics of increasing the capacity and operating costs of cyanide oxidation equipment combine to make land disposal of concentrated cyanides more attractive for this plant than treatment as a wastewater.

There is a very real question as to whether future disposal of concentrated cyanide will be by the traditional alkaline chlorine oxidation or by drummed landfills. There are no constituents in the cyanide wastes which would upset the effectiveness of the oxidation process. This efficiency can be as high as 99.6 percent [7]. However, proposed effluent guidelines for 1983, best available technology economically achievable, require that there be no discharge of wastewater pollutants. Achieving or approaching this goal may result in more cyanides being landfilled. However, expenditures already committed to treatment of cyanides in wastewater, high efficiency attainable by the alkaline chlorine oxidation process, and the present unavailability of landfills which can accept cyanides close enough to many plants are expected to weight against significant increases in land disposal of cyanides. An estimated 225 metric tons of concentrated cyanide wastes (equivalent to 60,000 gallons) are generated per year for electroplating operations in electronic connector and special electron tube manufacturing.

Table III-10 summarizes the occurrence of process wastes observed in surveyed plants by manufacturing process. As explained earlier, additional plant visits, especially within SIC 3679-Electronic Components Not Elsewhere Classified, would likely turn up more processes and more types of wastes. However, the common manufacturing processes and wastes of the electronic components manufacturing industry are represented in Table III-10. Process wastes considered by the contractor to be potentially hazardous are circled in Table III-10.

### Process Flow Diagrams

There is no general process flow diagram that would adequately typify manufacturing plants in the electronic components manufacturing industry. As has been noted, process flow diagrams representing one product area or four-digit SIC can be in substantial error for other plants within the same grouping. Nevertheless, five process flow diagrams are shown here for product areas in which at least two plants with similar operations were surveyed. The process flow diagrams are presented without quantification of raw material usage or waste generation to protect the confidentiality of information provided by the companies since all five diagrams are based on less than four plants each. None of the diagrams are intended to be descriptions of the operations of any one plant. Generally, information was integrated from the two or more plants visited in a product area to develop these example process flow diagrams. The example process flow

TABLE III-10

PROCESS WASTES GENERATED BY MANUFACTURING PROCESSES IN THE ELECTRONIC COMPONENTS MANUFACTURING INDUSTRY

X = Present in surveyed plants.

ⓧ = Considered hazardous by contractor.

| | HALOGENATED SOLVENTS | Trichloroethylene | 1,1,1 Trichloroethane | Perchloroethylene | Freon | Methylene chloride | Mixed halogenated solvents | Solvent sludges | NON-HALOGENATED SOLVENTS | Methanol | Acetone | Isopropylalcohol | Methyl Ethyl Ketone | Photoresist | Xylene | Stoddard solvent | Mixed non-halogenated solvents | METAL SCRAP | Mixed metal scrap (copper & steel primarily) | Precious metals | Solder dross or scrap | Beryllium alloy or oxide | WASTEWATER TREATMENT SLUDGES | Fluoride sludge | Electroplating sludges | Metal salt oxide or carbonate sludges | PLASTICS | Thermo plastic | Thermo setting | Silicon/Rubber | Epoxy resins | Magnetic tape waste | PAINT WASTES | Clean-up sludges | Air filters | OILS | Cutting Oil | Lubricating oils | Oil slurries | CYANIDE | CONCENTRATED ACIDS | OTHER LOW VOLUME AND NON-HAZARDOUS | NONE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Mechanical Material Removal** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Sawing and cutoff | | | | | | | | | | | | | | | | X | | | X | X | | ⓧ | | | | | | | | | | | | | | | ⓧ | ⓧ | | | | | |
| Grinding, polishing, or lapping | | | | | | | | | | | ⓧ | ⓧ | | | | | | | | | | X | | | | ⓧ | | | | | | | | | | | | | ⓧ | | | | |
| Scribing | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Silicon Scrap | |
| Grit blast | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Aluminum oxide | |
| Mechanical Etching | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Nickel-Chromium or Aluminum Dust | |
| **Material Forming** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Metal forming | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | ⓧ | | | | | |
| Glass forming | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Glass Scrap | |
| Non-plastic molding | | | | | | | | | | | X | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | Ceramic Scrap | |
| **Physical Property Modification** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Baking | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X |
| Milling | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Some metal oxides, ceramic dust | |
| Doping (Epitaxial deposition) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X |
| Crystal growth | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Aluminum oxide | |
| **Assembly Operations** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Hand soldering | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | |
| Wave soldering | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | |
| Furnace soldering | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X |
| Spot welding | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X |
| Gold bonding | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | |
| Brazing | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Mechanical lead attachment | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | |
| Wire winding | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X |
| Glass/metal seal | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | |
| Glass fritting | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | Glass Scrap | |
| **Chemical-Electrochemical Operations** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Electroplating | | | | | | | | | | | | | | | | | | | | | | | | | ⓧ | | | | | | | | | | | | | | | ⓧ | | | |
| Alkaline cleaning of metals | | | | | | | | | | | | | | | | | | | | | | | | | ⓧ | | | | | | | | | | | | | | | | | | |
| Acid cleaning and etching | | | | | | | | | | | | | | | | | | | | | | | | ⓧ | ⓧ | | | | | | | | | | | | | | | | ⓧ | | |
| Electroless plating | | | | | | | | | | | | | | | | | | | | | | | | | ⓧ | | | | | | | | | | | | | | | | | | |
| **Material Coating** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Dry booth painting | | | | | | | | | | | | | | | | | ⓧ | | | | | | | | | | | | | | | | | ⓧ | ⓧ | | | | | | | | |
| Vacuum metallizing | | | | | | | | | | ⓧ | ⓧ | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | |
| Printing/labeling | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | ⓧ | | | | | | | | | |
| Organic coating (dipping) | | | | | | | | | | | | | ⓧ | | ⓧ | | | | | | | | | | | | | | | | | X | | ⓧ | | | | | | | | | |
| Photoresist application | | | | | | | | | | | | | | ⓧ | ⓧ | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Gold termination | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | |
| Carbonate salt coating | | | | | | | | | | | | | | | | | ⓧ | | | | | | | | | X | | | | | | | | | | | | | | | | | |
| Phosphor deposition | | | | | | | | | | | | | | | | | | | | | | | | | | ⓧ | | | | | | | | | | | | | | | | | |
| **Molding and Forming Plastics** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Thermoforming plastics | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | X | | | | | | | | ⓧ | | | | | |
| Casting plastics | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | |
| **Solvent Cleaning and Drying** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Solvent cleaning | | ⓧ | ⓧ | ⓧ | ⓧ | ⓧ | ⓧ | ⓧ | | ⓧ | ⓧ | ⓧ | ⓧ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Solvent drying | | | | | ⓧ | | | | | ⓧ | ⓧ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

diagrams are presented to illustrate the basic flow of raw materials through manufacturing processes to the various waste streams. Treatment and disposal of the waste streams are discussed in Section IV of this report.

## NATURE OF PROCESS WASTES

### Introduction

As shown in Table III-10 the process wastes generated in electronic components manufacturing plants can be grouped into ten categories according to the major constituent of the waste. These categories are:

- Halogenated Solvents
- Non-halogenated Solvents
- Wastewater Treatment Sludges
- Plastics
- Oils
- Paint Wastes
- Metal Scrap
- Concentrated Cyanides
- Concentrated Acids or Alkalies
- Miscellaneous (generally generated in low volume and non-hazardous in nature)

Wastes in three of these categories -- metal scrap, concentrated cyanides and concentrated acids and alkalies -- are infrequently disposed of on the land.

Nearly all of the metal scrap generated is collected, stored separately in the plant, and sold to contractors for reclamation. The electronic components industry is a major consumer for precious metals such as gold, silver, platinum and palladium. Strict measures are taken to prevent loss of process wastes constituted of these metals. Copper, brass and steel scrap, while not as valuable, is usually generated in sufficient quantity to make resale profitable even for small plants. Small amounts of metal grindings and dust generated in the machine shops for electronic connector and special purposes electron tube manufacturing plants are not collected for salvage and are disposed of with floor sweepings. Generally, such unsalvaged metal scrap is not generated in this industry in quantities sufficient for concern. One exception to this statement is the waste generated from working beryllium oxide ceramic, beryllium/copper alloy and beryllium metal. Great caution is necessary in handling these bergllium materials and their wastes. Beryllium compounds can act locally on the skin to cause dermatitis and, if inhaled, can lead to respiratory system damage and even death if pneumonitis becomes severe [20]. Data on beryllium waste generation in surveyed plants is not sufficient to support projections of waste volumes for the industry. Very specizlized applications of beryllium materials in relatively small component parts indicate that the total beryllium wastes would be small.

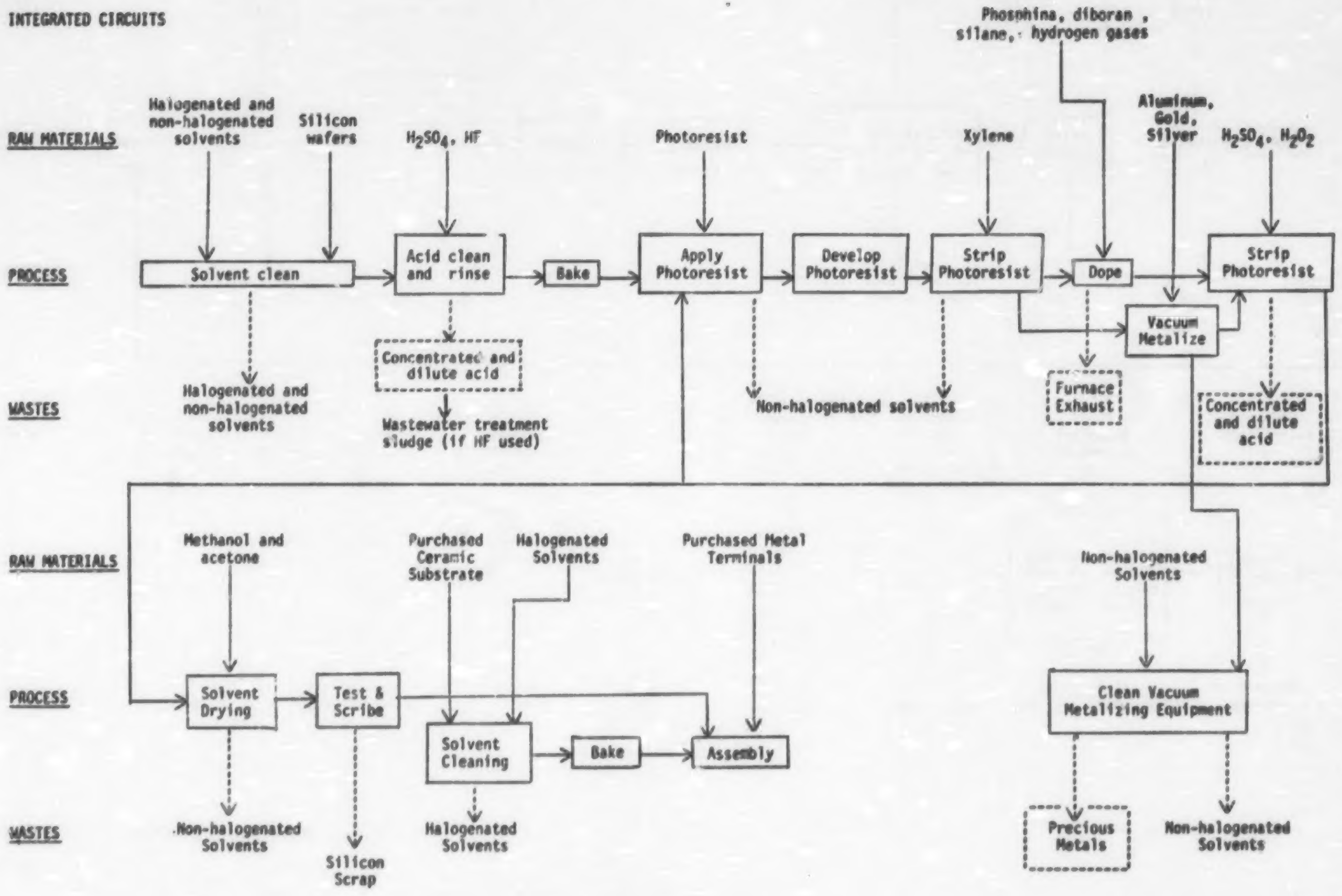
The potential for disposal of concentrated cyanide wastes on land has

# FIGURE III-1

# EXAMPLE PROCESS FLOW DIAGRAM

SIC 3674

INTEGRATED CIRCUITS


RAW MATERIALS
PROCESS
WASTES
Halogenated and non-halogenated solvents
Silicon wafers
$H_2SO_4$, HF
Photoresist
Xylene
Phosphina, diboran, silane, hydrogen gases
Aluminum, Gold, Silver
$H_2SO_4$, $H_2O_2$
Solvent clean
Acid clean and rinse
Bake
Apply Photoresist
Develop Photoresist
Strip Photoresist
Dope
Vacuum Metalize
Strip Photoresist
Halogenated and non-halogenated solvents
Concentrated and dilute acid
Wastewater treatment sludge (if HF used)
Non-halogenated solvents
Furnace Exhaust
Concentrated and dilute acid
RAW MATERIALS
PROCESS
WASTES
Methanol and acetone
Purchased Ceramic Substrate
Halogenated Solvents
Purchased Metal Terminals
Non-halogenated Solvents
Solvent Drying
Test & Scribe
Solvent Cleaning
Bake
Assembly
Clean Vacuum Metalizing Equipment
Non-halogenated Solvents
Silicon Scrap
Halogenated Solvents
Precious Metals
Non-halogenated Solvents

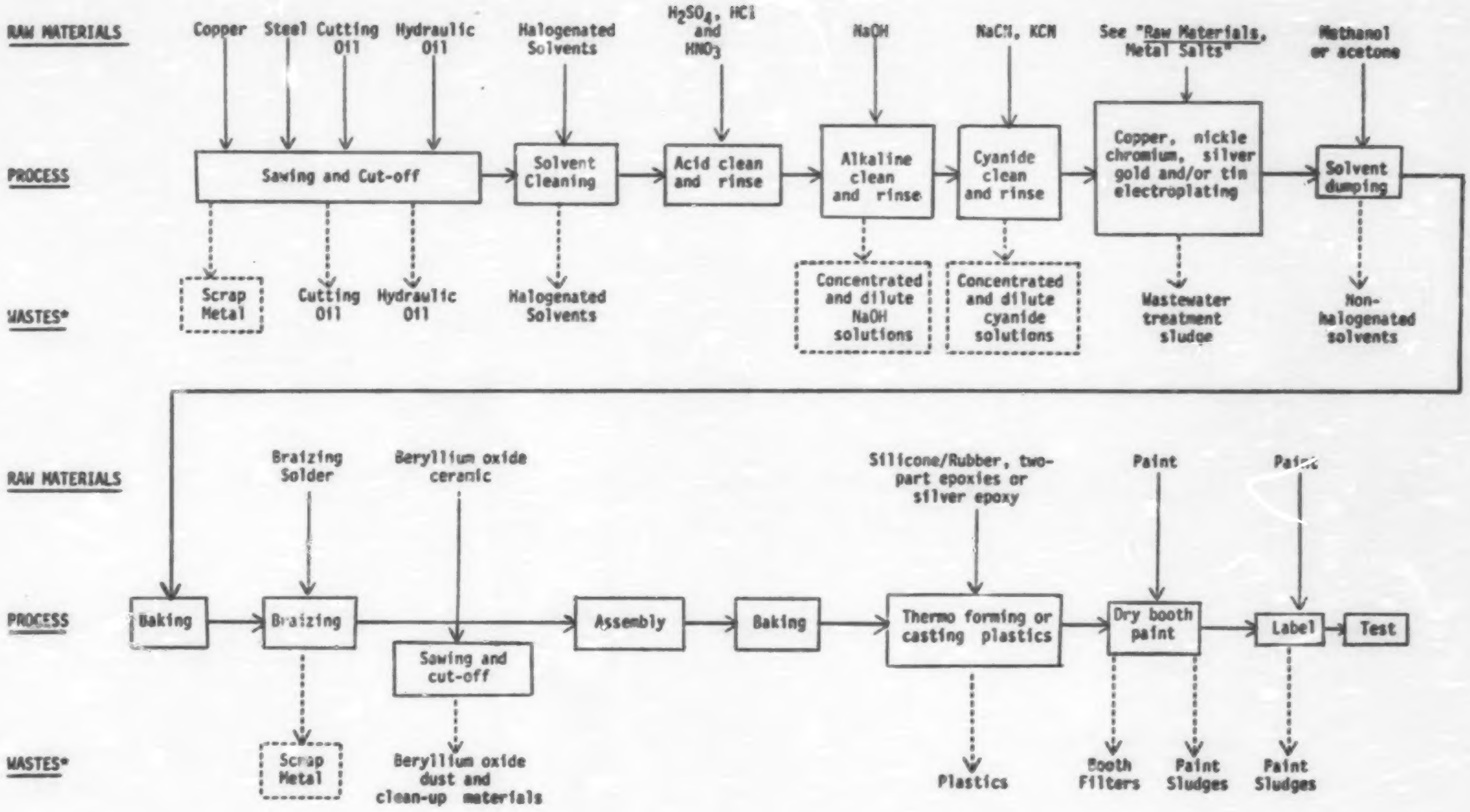
* - Significant wastes not commonly land disposed are outlined -

## FIGURE III-2

## EXAMPLE PROCESS FLOW DIAGRAM

SIC 3673

ELECTRON TUBES - TRANSMITTING AND SPECIAL PURPOSE


RAW MATERIALS
PROCESS
WASTES*
Copper
Steel
Cutting Oil
Hydraulic Oil
Halogenated Solvents
$H_2SO_4$, HCl and $HNO_3$
NaOH
NaCN, KCN
See "Raw Materials, Metal Salts"
Methanol or acetone
Sawing and Cut-off
Solvent Cleaning
Acid clean and rinse
Alkaline clean and rinse
Cyanide clean and rinse
Copper, nickle chromium, silver gold and/or tin electroplating
Solvent dumping
Scrap Metal
Cutting Oil
Hydraulic Oil
Halogenated Solvents
Concentrated and dilute NaOH solutions
Concentrated and dilute cyanide solutions
Wastewater treatment sludge
Non-halogenated solvents
RAW MATERIALS
PROCESS
WASTES*
Braizing Solder
Beryllium oxide ceramic
Silicone/Rubber, two-part epoxies or silver epoxy
Paint
Paint
Baking
Braizing
Sawing and cut-off
Assembly
Baking
Thermo forming or casting plastics
Dry booth paint
Label
Test
Scrap Metal
Beryllium oxide dust and clean-up materials
Plastics
Booth Filters
Paint Sludges
Paint Sludges

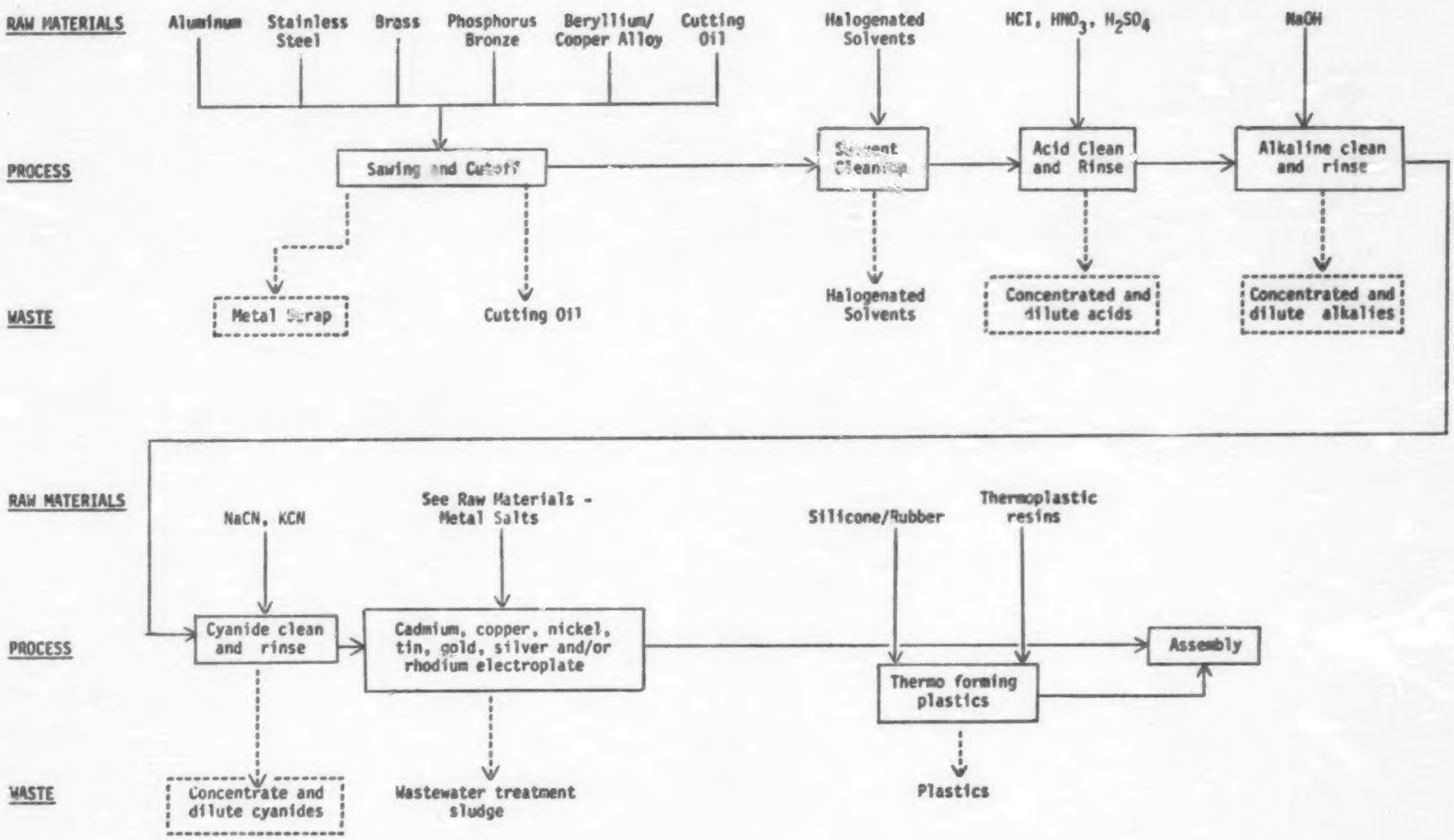
* - Significant wastes not commonly land disposed are outlined -

FIGURE III-3

EXAMPLE PROCESS FLOW DIAGRAM

SIC 3678

ELECTRONIC CONNECTORS


RAW MATERIALS
Aluminum
Stainless Steel
Brass
Phosphorus Bronze
Beryllium/ Copper Alloy
Cutting Oil
Halogenated Solvents
HCI, $HNO_3$, $H_2SO_4$
NaOH
PROCESS
Sawing and Cutoff
Solvent Cleanup
Acid Clean and Rinse
Alkaline clean and rinse
WASTE
Metal Scrap
Cutting Oil
Halogenated Solvents
Concentrated and dilute acids
Concentrated and dilute alkalies
RAW MATERIALS
NaCN, KCN
See Raw Materials - Metal Salts
Silicone/Rubber
Thermoplastic resins
PROCESS
Cyanide clean and rinse
Cadmium, copper, nickel, tin, gold, silver and/or rhodium electroplate
Thermo forming plastics
Assembly
WASTE
Concentrate and dilute cyanides
Wastewater treatment sludge
Plastics

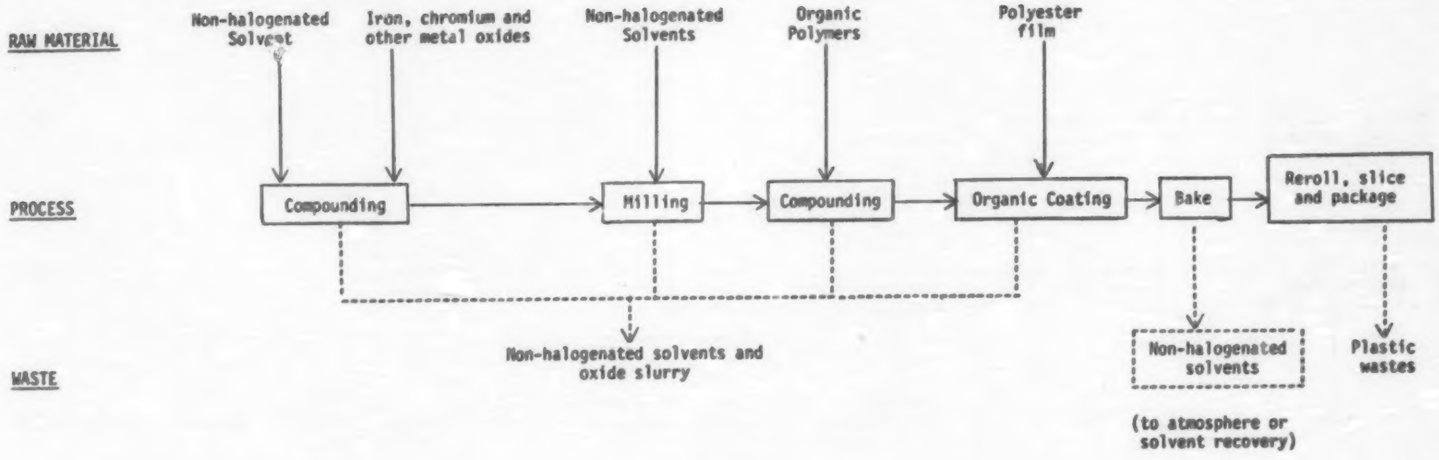
* - Significant wastes not commonly land disposed are outlined - ☐

## FIGURE III-4

## EXAMPLE PROCESS FLOW DIAGRAM

SIC 3679

MAGNETIC TAPE


RAW MATERIAL
PROCESS
WASTE
Non-halogenated Solvent
Iron, chromium and other metal oxides
Non-halogenated Solvents
Organic Polymers
Polyester film
Compounding
Milling
Compounding
Organic Coating
Bake
Reroll, slice and package
Non-halogenated solvents and oxide slurry
Non-halogenated solvents
(to atmosphere or solvent recovery)
Plastic wastes

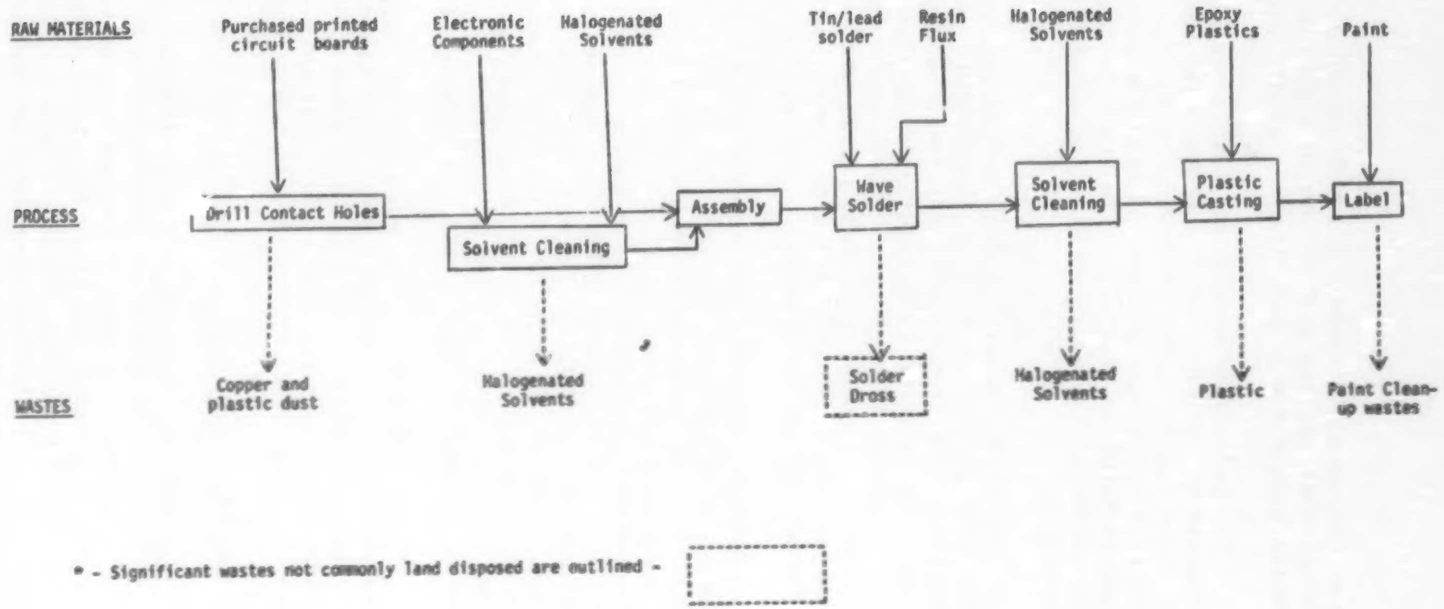
* - Significant wastes not commonly land disposed are outlined - ┆  ┆

# FIGURE III-5

## EXAMPLE PROCESS FLOW DIAGRAM

SIC 3679

COMPLEX COMPONENTS


RAW MATERIALS
PROCESS
WASTES
Purchased printed circuit boards
Electronic Components
Halogenated Solvents
Tin/lead solder
Resin Flux
Halogenated Solvents
Epoxy Plastics
Paint
Drill Contact Holes
Solvent Cleaning
Assembly
Wave Solder
Solvent Cleaning
Plastic Casting
Label
Copper and plastic dust
Halogenated Solvents
Solder Dross
Halogenated Solvents
Plastic
Paint Clean-up wastes

* - Significant wastes not commonly land disposed are outlined -

been discussed in connection with the cyanide cleaning process. It is expected that cyanide wastes generated by the electronic components manufacturing industry will not become a significant waste stream for land disposal.

The concentrated acid and alkali wastes generated in the industry are amenable to treatment as a wastewater by neutralization. While components of these wastes could include fluorides and any of the metals used in the industry which must be removed from the wastewater, and will ultimately be land disposed as sludges, it is unlikely that a significant proportion of the untreated concentrated acid and alkali wastes will be containerized and landfilled.

The miscellaneous process wastes recognized during the survey are generally generated in low volumes for the industry although the amount generated from individual plants must be significant. For instance, glass scrap from electron tube manufacturing plants becomes a locally significant waste. These miscellaneous process wastes are not considered by the contractor to be hazardous. Most of the miscellaneous process wastes, when land disposed, are combined with plant trash such as packaging and cafeteria wastes for landfill along with municipal solid waste.

Included in the miscellaneous process waste category is an atypical waste containing polychlorinated biphenyls generated by a resistor manufacturer. PCB's are used here to impregnate the composition resistors as a means of water-proofing them. The composition material trimmed off after molding, which is otherwise innocuous, contains the PCB. This waste is collected and transported to an industrial incinerator for destruction. Replacement of PCB's by a non-toxic substitute in this plant is planned. Other uses of PCB's in the electronic components manufacturing industry, i.e., in capacitor and transformer manufacturing, were recognized in the plant surveys conducted for this study. No quantification of PCB containing wastes in these product areas can be made from the survey data, therefore.

These four waste categories are not significant to this study of land disposed industrial process wastes for the reasons mentioned. The remaining six waste categories are discussed below. These waste categories are designated as the significant waste streams of the electronic components manufacturing industry destined in whole or in part for land disposal.

## Waste Categories

Halogenated Solvents - The process waste in this waste stream show a wide range in the degree of contamination by other materials. In plants where relatively small volumes of halogenated solvents are used as high efficiency cleaners, the waste can be sufficiently uncontaminated for reuse in other industries without distillation. However, also included in this waste stream are still bottoms from in-plant solvent distillation, which can have high concentrations of oils, soldering flux, metal particles, non-metal particles, and metal ions.

The best established toxicity effect of halogenated solvents is their narcotic effect when present in air above threshold concentrations.

Although these values are much lower than their vapor pressures, it is unlikely that the threshold concentrations would be exceeded anywhere except inside buildings. Hazards to landfill personnel due to inhalation of the solvents' vapors would be likely, therefore, only under very unusual circumstances. Solvent wastes that are stored on-site prior to disposal are normally stored in outside areas or in well-ventilated buildings.

A greater hazard in the disposal of halogenated solvent wastes is the potential for generation of highly toxic gases if they are heated to temperatures above 250°F. Such heating can occur in landfills where ash or flammable materials susceptible to spontaneous combustion are disposed. To the contractor's knowledge, the probability and actual toxic effects of heating halogenated solvents to this temperature have not been thoroughly studied. The property of releasing toxic gasses due to heating has not, therefore, been included as one of the criteria for potentially hazardous wastes in this report.

The effects of releasing the halogenated solvent wastes to the environment is difficult to assess with available information. All of these solvents are aliphatic chlorinated hydrocarbons which have potential for damage to the heart, liver, and kidney proportional to the saturation of the molecular structure with chlorine [20]. Data on damage to humans by aliphatic chlorinted hydrocarbons is generally collected only in relation to medical and industrial usage, not from situations where environmental concentrations of the materials are involved. In the absence of published criteria for halogenated solvents in water and in light of relatively high doses required to produce toxic effects[1], the presence of halogenated solvents in a process waste does not render the waste hazardous for the purpose of this report.

Many of the solvent wastes included in this waste stream, however, contain oil and heavy metal impurities which are toxic to man and/or wildlife. Table III-11 presents the analysis of the two halogenated solvent wastes collected from electronic component plants. These samples show the wide range of solids content for this waste stream. Also noteworthy is the presence of lead in both samples with the amount of leachable lead in the trichloroethane sample being particularly high at 23.2 mg/l. Flash points for the samples indicate that flammable impurities were present in the sample since the halogenated solvents have no flash point if uncontaminated.

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[1] The most up-to-date summary of the toxic effects of chemical substances [42] does not list any toxic dose by oral administration for any of the halogenated sovlents. Lethal oral doses reported range from 857 mg/kg for trichloroethylene in more than 9470 mg/kg for 1,1,1 trichloroethane in guinea pigs. The lethal oral dose for man would require ingestion of 145 ml. of pure solvent by a 100 pound person. The only solvent in this group for which data on carcinogenicity is available is trichloroethylene. A dose of 351 grams/kg administered orally and intermittently over a period of 78 weeks caused cancerous tissues in mice [42]. This is a near-lethal dose given over a long period of time. The U.S. Food and Drug Administration permits decaffinated coffee to have a concentration of trichloroethylene of 25 mg/1 [31].

The proportions of this waste stream contributed by the various solvents and sludges is estimated by the volumes of each generated in surveyed plants. Estimated annual volume of these waste solvents in the plants from which data was available were used to determine the following percentages of generation:

| Waste Solvent | Percent of Total Estimated Volume (weight basis) in Surveyed Plants |
|---|---|
| Perchloroethylene sludge | 38.4* |
| Trichloroethylene | 29.2 |
| Mixed solvents | 12.5 |
| Perchloroethylene | 6.3 |
| 1,1,1 trichloroethane | 6.1 |
| Freon | 4.5 |
| Methylene chloride | 1.4 |
| Freon sludge | .8 |
| Mixed sludge | .7 |
| Trichloroethylene sludge | .1 |
| | 100.0 |

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*The large percentage of perchloroethylene sludge is due to extensive use of the solvent in one large plant.

Non-halogenated Solvents - As is the case with the halogenated solvent wastes, the non-halogenated solvents wastes show great variability in their degree of contamination. Perhaps the least contaminated are the methanol and acetone wastes that result from drying operations. Rinse water remaining from acid cleaning operations is diluted in solvent baths. The solvents dry much faster on the components than water alone up to a point where the water content becomes too high. The baths are then usually sent to solvent reclaimers where they require only dewatering. At the other extreme of contamination are solvents used as vehicles for lapping compounds or for cleaning lapping compounds for components.

Due apparently to the lower cost of non-halogenated solvents there is less effort put forth in segregating these wastes for reclamation except for those, like methanol and acetone used in drying operations, which are still comparatively clean after use.

Nearly all of the non-chlorinated solvents used by the electronic components manufacturing industry have flash points below 100°F. Exceptions, such as polyvinyl alcohol and cyclohexanone are used for specialized applications and represent a small proportion of the non-halogenated solvent

## TABLE III-11

## CHEMICAL ANALYSIS OF HALOGENATED SOLVENT WASTES FROM ELECTRONIC COMPONENT MANUFACTURING PLANTS

| Sample Description | % Drying Loss 103°C | % Ignition Loss 550°C | % Solids 550°C | pH | Oil & Grease (mg/kg) | % $H_2O$ | Flash Point °F | T.C.E. % | Cd | Cr | Cu | Fe | Pb (mg/kg) | Zn | Ni | Mn | $F^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | Water leached | | | | | |
| | | | | | | | | | <0.02 | <0.02 | 0.10 | 0.08 | 23.2 | 0.48 | 0.18 | <0.02 | |
| | | | | | | | | | | | | As received | | | | | |
| 1,1,1 Trichloroethane from immersion degreasing of ferrites | 99.9 | 0.06 | 0.04 | 5.7 | 94 | 0.2 | 118 | 75.0* | <0.02 | 0.02 | <0.03 | 5 | 125 | 2.2 | 2 | <0.02 | |
| | | | | | | | | | | | | Water leached | | | | | |
| | | | | | | | | | <0.02 | <.06 | <.05 | 0.2 | <.8 | 0.3 | <.08 | | 1.5 |
| | | | | | | | | | | | | As received | | | | | |
| Freon sludge from vapor degreasing of complex components | 53.14 | 36.97 | 9.89 | 5.2 | | 0.02 | 150 | | .05 | 0.1 | 1.2 | 198 | 23 | 4.9 | 0.8 | | |

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* 1,1,1 trichloroethane

waste stream. The entire waste stream is considered here to be flammable since the proportion of non-flammable solvents is small.

Analytical data for non-halogenated solvent wastes collected during plant visits are presented in Table III-12. The solids content of those wastes analyzed are low. No heavily contaminated wastes in this waste stream appear in this sampling. Chromium was present in all three samples at concentrations slightly above the limit of detection by the method used. The only other heavy metal concentrations of note are the 21 mg/l of lead and the 455 mg/l of zinc present in the glass slurry. Only small percentages of the lead and zinc in this sample leach out in water, however.

The proportions of this waste stream contributed by the various solvents is estimated by the volumes of each generated in surveyed plants. Estimated annual volume of these waste solvents in the plants for which data was available were used to determine the following percentages of occurrence in the industry:

| Waste Solvent | Percent of Total Estimated Volume (weight basis) in Surveyed Plants |
|---|---|
| Mixed solvents (includes some halogenated solvents mixed with non-halogenated solvents) | 67.7% |
| Methanol | 14.4 |
| Acetone | 12.4 |
| Isopropyl Alcohol | 2.8 |
| Photoresist and developers e.g., xylene | 1.8 |
| Polyvinyl alcohol | .5 |
| Stoddard solvent | .4 |
| Methyl Ethyl Ketone<br>Xylene | .1 |
| | 100.1% |

Not included in this waste stream or in calculation of the above percentages are solvents used for cleaning painting equipment. These wastes are included in the painting wastes.

The high percentage of mixed solvents reflects a lesser concern for segregation of non-halogenated solvents when compared to the halogenated solvents.

Wastewater Treatment Sludges - Water-carried wastes significant to sludge generation in surveyed plants can be grouped into three categories:

1. particulates - primarily metal oxides and metal salts
2. metal ions - including all of the metals used for plating plus common metal contaminants such as lead, zinc, and iron.

TABLE III-12

CHEMICAL ANALYSIS OF NON-HALOGENATED SOLVENT WASTES FROM ELECTRONIC COMPONENT MANUFACTURING PLANTS

| Sample Description | % Drying Loss 103°C | % Ignition Loss 550°C | % Solids 550°C | pH | % $H_2O$ | Flash Point °F | T.C.E % | Cd | Cr | Cu | Fe | Pb (mg/kg) | Zn | Ni |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mixed cleaning solvents isopropyl alcohol & trichloroethylene | | | | | | | | | | | Water leached | | | |
| | | | | | | | | <0.02 | 0.02 | 0.4 | <0.08 | <1.0 | 0.92 | 0.21 |
| | | | | | | | | | | | As received | | | |
| | 99.89 | 0.10 | 0.01 | 4.8 | 4.8 | 69 | 18.5 | <0.02 | 0.06 | 0.5 | 0.4 | <0.3 | 1.0 | 0.2 |
| Semiconductor photoresist & xylene developer | | | | | | | | | | | Water leached | | | |
| | | | | | | | | <0.02 | <0.02 | <0.06 | <0.08 | <1.0 | 1.32 | |
| | | | | | | | | | | | As received | | | |
| | 99.80 | 0.20 | 0.01 | 5.6 | 0.4 | 76 | | <0.02 | 0.02 | <0.05 | 0.5 | <0.3 | 2.9 | |
| Glass slurry - isopropyl alcohol base | | | | | | | | | | | Water leached | | | |
| | | | | | | | | <0.02 | <0.02 | <0.06 | <0.08 | 4.0 | 4.26 | <0.06 |
| | 99.88 | 0.01 | 0.11 | 10.5 | 2.1 | 54 | | | | | As received | | | |
| | | | | | | | | <0.02 | 0.03 | <0.06 | <0.1 | 21 | 455 | <0.06 |

3. fluorides - as fluorides ion or as silico-fluorides from silicon wafer and glass etching.

Processes used in these plants to separate these wastes from the wastewater include sedimentation, coprecipitation at elevated pH, and filtration. Most of the wastewater treatment sludges from the surveyed plants included water-carried wastes from several manufacturing processes. Quantification of the percent of particulate contaminants, metal ion contaminants, and fluorides from survey plant data is not feasible without a much more exhaustive sampling and analysis program than that conducted for this study.

Wastewaters containing only particulates are treated by either sedimentation or filtration. The sludge generated is easily dewatered and relatively inert although small particle size of some of the metal oxides and solubility of the metal salts could result in the release of metal ions from the sludge over time.

Electroplating wastewaters, acid wastewaters from metal cleaning, and many combined wastewaters require pH adjustment to cause the coprecipitation of metal hydroxides. All three of the common wastewater treatment processes can be used in treatment of such wastes. However, pH adjustment followed by sedimentation of the metal hydroxides is the typical combination for treatment. Sludges from pH adjustment of these wastewaters are often difficult to dewater.

The source of fluorides in wastewaters from SIC's 3671, 3672, 3674 and crystal manufacturing is hydrofluoric acid used in cleaning glass, silicon or quartz. Treatment processes apparently designed specifically for the removal of fluorides were present in only one plant visited. Here, addition of lime resulted in the precipitation of calcium fluoride, $CaF_2$. Lime precipitation of fluorides at a pH of 11 will remove fluorides down to a concentration of 10-20 mg/l. The solubility of calcium fluoride prevents more efficient removals. A typical effluent limitation of 1.5 mg/l would require a two stage operation inlcuding lime precipitation followed by adsorption of alumina or bone char or ion exchange. Acid regeneration waters from the second stage recycled to the lime precipitation step would result in almost complete conversion of fluoride consumed in the plant to calcium fluoride [32]. The only data on fluoride concentrations in untreated wastewater from surveyed plants is from a grab sample taken at a semiconductor plant. Removal of the 440 mg/l of fluoride in the wastewater would result in the generation of approximately 15,000 pounds of calcium fluoride per million gallons of wastewater. At a maximum solids concentration of five percent that might be obtained without concentration, 36,000 gallons of sludge per million gallons or 3.6 percent of the wastewater flow would have to be disposed of by concentration and/or landfill. Regulatory control of fluorides in wastewater effluents has potential for dramatically increasing wastewater sludge generation from the industry since: (1) there is very little attention being paid to fluoride removal at present in the industry; and (2) most other significant constituents in wastewaters are already being removed by most of the plants which generate them. Because of its size and its heavy use of hydrofluoric acid and because many of these plants currently do not provide chemical precipitation of their wastewaters, the semiconductor industry will likely be the most affected by fluoride removal requirements.

Analytical data for wastewater treatment sludges collected during plant visits are presented in Table III-13. These samples demonstrate the wide range of solids concentrations possible in this waste stream. The 98 percent solids concentration in the metal oxide sludge is considered to be atypically high, however.

While the metal concentrations in these sludges are almost universally high compared with other waste streams, the amounts of metals that leached with water are very small fractions of the metals present. This data fails to show that the Federal Water Quality Criteria would be violated by the leachates. However, solubilities of the metal hydroxides are increased as pH of sludge and surrounding groundwater in a landfill decreases. Short term release of metals from these sludges is small. Sludges exposed to percolating groundwaters which typically are neutral to slightly acidic can be expected to gradually decompose and release metals for long periods of time. High concentrations of all the metals tested indicate that these sludges would provide a reservoir of potentially soluble metals if disposed of in such a manner as to be exposed to percolating groundwaters.

In addition to metals, at least one of the sludge samples contained fluorides. The concentration reported, 12 mg/kg, is in terms of the amount of fluoride leached per kilogram of sludge by two volumes of distilled water. The aqueous concentration of fluoride in the leachate was 6 mg/l, well above the maximum allowable concentration for drinking water of 1.4 - 2.4 mg/l [13]. Total fluorides were not analyzed for this sample by a complete chemical analysis of a wastewater treatment sludge provided by a semiconductor firm shows that calcium fluoride constituted one percent of the sludge solids equivalent to a concentration of approximately 1300 mg/l - fluoride in the sludge. Solubility of the calcium fluoride is dependant upon pH so that it would gradually be leached from the sludge as would the metals.

Plastics - Included in this waste stream are plastic scrap from trimming injection and transfer molded components, rubber scrap from silicon/rubber molding, unused portions of mixed epoxies, and polyester film scrap from slicing and packaging magnetic recording tape. Plastic process wastes which do not enter the waste stream include a portion of the thermoplastic type plastic scrap which can be recycled in-plant and epoxies containing silver powder which are collected and returned to the manufacturer for credit on the silver.

The durability of plastics is determined in part by the degree of plasticizer retention by the plastics. Plasticizer migration results in embrittlement of the plastic part. Since the durability of most electronic components is of prime consideration in their design, the use of stable plasticizers in electronic component plastics is thought to be common practice.

Data collected during plant visits would indicate that the highest volume waste material in this waste stream is magnetic recording tape scrap.

## TABLE III-13

## CHEMICAL ANALYSIS OF WASTEWATER TREATMENT SLUDGES FROM ELECTRONIC COMPONENT MANUFACTURING PLANTS

| Sample Description | % Drying Loss 103°C | % Ignition Loss 550°C | % Solids 550°C | pH | Cd | C | Cu | Fe | Pb (mg/kg) | Zn | Ni | Mn | $F^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Water leached | | | | | |
| Sludge from Electroplating Wastewaters | 90.72 | 0.88 | 8.40 | 8.1 | < 0.02 | < 0.04 | 2.6 | 0.2 | < 1.0 | < 0.02 | 0.5 | | |
| | | | | | | | | As received | | | | | |
| | | | | | 102 | 700 | 1,650 | 7,850 | 58 | 105 | 1,980 | | |
| | | | | | | | | Water leached | | | | | |
| Metal Oxide Sludge | 1.10 | 3.19 | 95.71 | 7.6 | < 0.06 | < 0.04 | 0.4 | 0.4 | < 1.0 | 3.26 | 1.2 | 30 | |
| | | | | | | | | As received | | | | | |
| | | | | | 1.8 | 22 | 120 | 106,800 | 2.7 | 38,700 | 1,890 | 40,800 | |
| | | | | | | | | Water leached | | | | | |
| Sludge from Electroplating Wastewaters | 96.03 | 0.90 | 3.07 | 8.0 | < 0.02 | < 0.02 | 4.0 | 0.2 | 1.0 | < 0.02 | 4 | | 12 |
| | | | | | | | | As received | | | | | |
| | | | | | 5.1 | 320 | 8,090 | 930 | 28 | 786 | 1,690 | | |

Much of this tape scrap is coated with the metal oxides, carbon, graphite and organic binding compounds (other plastics) that give the tape its functional properties. Because they are tightly bound by the organic binders to the film, potentially toxic metal oxides, such as chromium oxide, would not be likely to leach from the tape. Release of chromium oxide could be effected by dissolution of the organic binders by solvents or by incineration of the waste tape. The possibility of these occurrences in a landfill has not been evaluated.

The remainder of this waste stream is also considered to be innocuous as sanitary landfill material.

Hydraulic and Cutting Oils - A variety of process wastes are included in this waste stream. The common characteristic for these process wastes is the presence of a significant amount of oil. The oils, based upon plant survey data, are all petroleum distillates and range from approximately five percent of waste for the water soluble cutting oils to essentially 100 percent of the waste for leaked or replaced hydraulic fluids. The most common waste in the waste stream is water soluble cutting oils. These are used in both metal fabricating operations and in ferrite and crystal grinding operations. Generally, the water soluble cutting oils are recirculated between the lathes or other cutting equipment and settling tanks where particles removed from the metal or non-metal stock are settled out. The slurry made up of sedimented particles and cutting oil is periodically collected and disposed of. The solids content of this waste can be very high and is, of course, dependent upon the type of material being worked.

Oil-based lapping compounds represent a smaller portion of this waste stream. Alumina, diamond powder and carborundum are intentional additives in the lapping compounds. Particles added to the lapping compounds from the component part plus some of the solvents used to clean the part between successive lapping cycles are included in the waste from this operation.

Waste hydraulic oils generally do not contain the large amount of particulate matter present in other oil wastes. However, long periods of contact, sometimes at high operating temperatures, with metals lining the conduits of the hydraulic machinery result in heavy metal contamination of the oils [33].

Chemical analysis of two lapping compound wastes are presented in Table III-14. An insufficient volume of the mineral seal oil-based copping was collected to perform leachate tests.

The potential for high concentrations of heavy metals in oil wastes is demonstrated by the analytical results for the mineral seal oil based lapping compound. Significant metal concentrations, especially lead and chromium, are also expected in the cutting oil wastes generated in metal working machine shop. Based upon data gathered for a related report [33] lead concentrations as high as 2,275 mg/kg and chromium concentrations as high as 1,340 mg/kg are to be found in cutting oil wastes. These metals are generally in particulate form and would be solubilized in a landfill situation slowly and in inverse proportion to particle size.

Oils present in this waste stream could cause taste and odor problems in water supplies if the wastes are improperly disposed. A numerical limit on the order of 0.01 mg/l of oil is expected to be set for receiving waters for the protection of fish and wildlife [34].

Paint Wastes - Included in this waste stream are discarded filters from dry booth spray painting operation, solvent and paint soiled clean up rags, and solvents used for paint clean up. The paint waste stream, therefore, encompasses a variety of materials. All of the wastes, however, contain paint pigments. Lead, zinc, and chromium are frequent components of these pigments. In addition, the solvents used to thin paint and to clean up painting equipment are typically non-chlorinated types such as acetone, alcohols and xylene which have flash points below 100°F.

Paint wastes are typically disposed of sporadically and, except for the cleaning of vats used for dip coating, they are seldom disposed of in significant quantities at any one time. Because of the nature of paint waste generation, little attention is paid to their segregation and disposal. The usual disposal method, therefore, involves mixing with other plant trash in dumpsters for sanitary land filling.

Chemical analysis of two paint waste samples is presented in Table III-15. Chromium and lead concentrations in the samples are significant as would be expected. However, the solubility of these metals in water varies greatly between the two samples. This difference in metals solubility may be the result of the pH difference between the samples. The flash point of the acetone-based waste is below 100°F and, so, is considered flammable. Although flash point was not analyzed for the other sample, a flash point above 84°F and possibly below 100°F is postulated because of the presence of xylene.

## Identification of Potentially Hazardous Waste Streams

Of the ten categories of process wastes identified at the beginning of the previous section, all include some materials which are hazardous according to the criteria discussed under "Criteria for the Determination of a Potentially Hazardous Waste." The definition of waste stream that is used here is that it is a category of process wastes, a significant quantity of which was land disposed by surveyed plants. This definition excludes metal scrap, concentrated cyanides, and concentrated acids and alkalies from designation as waste streams. The typical disposal practices for these wastes were discussed in the previous section, "Nature of Process Wastes." Beryllium wastes are the only materials in these categories which are likely to be typically land disposed. The amount of beryllium wastes generated in the industry is not quantifiable from the data collected in plant visits. Based upon the restricted use of beryllium-containing raw materials, it is likely that the amount of beryllium wastes generated by the industry is small.

The miscellaneous waste stream includes the atypical polychlorinated biphenyl waste mentioned previously. Discontinuation of PCB use in the

## TABLE III-14

## CHEMICAL ANALYSIS OF OIL-CONTAINING WASTES FROM ELECTRONIC COMPONENTS MANUFACTURING PLANTS

| Sample Description | % Drying Loss 103°C | % Ignition Loss 550°C | % Solids 550°C | pH | Flash Point °F | Cd | Cr | Cu | Fe | Pb (mg/kg) | Zn | Ni |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lapping Compound - Mineral Seal Oil Based | | | | | | | | | As received | | | |
| | 8.58 | 6.00 | 85.42 | | | 0.3 | 0.5 | 2,570 | 105 | 73 | 458 | 4 |
| Lapping Compound - Kerosene Based | | | | | | | | | Water leached | | | |
| | 85.74 | 6.19 | 8.07 | 4.8 | 120 | <0.02 | 0.06 | <0.06 | 126 | <1.0 | <0.02 | 0.6 |
| | | | | | | | | | As received | | | |
| | | | | | | <0.02 | 4 | 0.1 | 270 | <0.5 | 0.2 | 0.7 |

## TABLE III-15

### CHEMICAL ANALYSIS OF PAINT WASTES FROM ELECTRONIC COMPONENTS MANUFACTURING PLANTS

| Sample Description | % Drying Loss 103°C | % Ignition Loss 550°C | % Solids 550°C | pH | Flash Point °F | Cd | Cr | Cu | Fe | Pb (mg/kg) | Zn | Ni |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Water leached | | | | |
| Lacquer Equipment Cleanup Wastes - Acetone Based | 98.50 | 1.44 | 0.01 | 4.5 | 70 | <0.02 | 0.6 | 0.16 | 0.6 | 3.4 | 0.36 | |
| | | | | | | | | As received | | | | |
| | | | | | | <0.02 | 41 | 0.5 | 10 | 178 | 0.6 | |
| | | | | | | | | Water leached | | | | |
| Dip Varnishing Equipment Clean-up Wastes — Xylene based | 70.22 | 18.31 | 11.47 | 7.5 | | <0.06 | <0.04 | <0.14 | 0.8 | 1.0 | <0.06 | <0.2 |
| | | | | | | | | As received | | | | |
| | | | | | | <0.1 | 390 | 37 | 360 | 582 | 1,996 | 4 |

surveyed plant in the near future will eliminate the only hazardous material recognized in the miscellaneous waste stream.

The hazardous characteristics of the remianing six waste streams is summarized below:

Halogenated Solvents - The toxicity of the halogenated solvents as air contaminants is well established [30]. Trichloroethylene, the most commonly used solvent in this group, has also been found to be photochemically reactive [29]. However, toxicity of the halogenated solvents in soil, groundwater, or surface water is not established in available literature except as extrapolated from industrial air contaminant standards [1]. In lieu of more concrete information on toxicity and the fate of the solvents in land disposal operations, classification of this waste stream as potentially hazardous on the basis of solvent toxicity is not proposed at this time.

Solvents are highly susceptible to contamination by materials which can be readily identified as being hazardous, however. For example, one of the two halogenated solvent waste samples analyzed for heavy metals for this study contained 125 mg-lead/kg. Approximately one-fifth of the lead in that sample leached into water at neutral pH.

The types and concentrations of toxic contaminants in waste solvents would be dependent upon the use to which they are put and the degree of particulate or ionic contamination allowed. In order to estimate a crude ratio of hazardously contaminated solvent wastes to total solvent wastes, the heavy metals analyses for the five solvent samples collected for this study (halogenated and non-halogenated) were examined for the amount of leachable metal in them. Two of the samples, one halogenated solvent and the other non-halogenated, contained hazardous concentrations of leachable lead. Cadmium, chromium, copper, and iron did not leach to hazardous levels in any of the five samples. Leachable zinc was found in all five samples at concentrations of 0.1 to 4.26 mg/kg of solvent.

Although zinc can be toxic to sensitive freshwater fish and invertebrates, the solvent waste streams are not judged to be hazardous due to this constituent. Drinking water criteria (5.0 mg/l-zinc) are higher than zinc concentrations in the leachates (equivalent to approximately one-half of the leachable concentrations reported for the solvent since the solvent samples were mixed 2:1 with water for the leachate test). The sensitivity of aquatic species to zinc is highly variable and dependent on several water quality parameters. While there is a possibility of adverse impact from the zinc contained in improperly disposed solvent wastes, the criteria for judging the impact are not sufficiently developed to be of utility in this study.

The determination that two-fifths of both solvent waste streams are potentially hazardous is based on the presence of hazardous amounts of leachable lead in two out of the five waste solvent samples. This basis for quantifying the potential hazardousness of these waste streams is admittably incomplete. More information on the toxicity of halogenated solvents to aquatic and terrestrial biota, the potential for generation of highly toxic gases from heating halogenated solvents and more data on the heavy metal content of both classes of solvent wastes is needed.

Non-halogenated Solvents - In addition to the leachable heavy metals content of waste solvents, the non-halogenated solvents used in surveyed plants with few exceptions had flash points below the standard for flammability, 100°F. The entire waste stream is classified as potentially hazardous for this reason.

Wastewater Treatment Sludges - Heavy metals and fluorides are present in the wastewater treatment sludges generated by electronic component manufacturing plants. At the elevated pH's of these sludges, pH 8 and above, the metals are insoluble and only appear in water leachates in concentrations near or below the limits of analytical detection by the methods used. (See Appendix C). Fluorides, on the other hand, appear in the leachates in concentrations of approximately 5 to 20 mg/l at the pH of the sludges. These concentrations exceed the National Interim Primary Drinking Water Regulations standard for fluoride of 1.4 to 2.4 mg/l. (temperature dependent).

At lower pH's the metal hydroxides and the fluorides become more soluble in water. These sludges are expected to decompose in time if disposed of in landfill situations where they would come into contact with groundwater or acidic wastes. Suspected long term, gradual release of heavy metals and fluorides from these waste sludges is the basis for classifying them as potentially hazardous.

Plastics - Plastic wastes are not hazardous by the criteria established for the purpose of this study. Two aspects of plastics disposal, release of plasticizers and conversion to toxic gases if improperly burned, may pose unquantified hazards for disposal of specific plastics or for disposal of plastics in combination with flammable materials. The risk of these hazards cannot be assessed adequately from data collected for this study.

Hydraulic and Cutting Oils - Improperly disposed oil wastes present a hazard to fish and wildlife in very low concentrations. A limit on the order of 0.01 mg/l is expected to be set for oil in fresh water [34]. Adverse effects on public drinking water supplies involving taste and odor problems have been caused by improperly disposed oils. The entire waste stream is, therefore, classified as potentially hazardous. The presence of dissolved and particulate metals in much of the waste stream adds to the hazardous nature of the oil wastes.

Paint Wastes - Chromium and lead are used extensively in paint pigments and are present in significant concentrations in paint wastes whether the wastes are dry, such as dry booth filters, or solvent soaked. The widespread presence of these metals is the basis for classifying this waste stream as potentially hazardous. Other metals, especially zinc, are also present and contribute to the hazard.

In addition to the heavy metal content, a substantial fraction of this waste stream has flammable solvents as a constituent. As estimated one-half of the waste stream is flammable due to the presence of these solvents.

## QUANTITIES OF PROCESS WASTE STREAMS

### Data Base

Data collected in conjunction with twenty-two plant visits plus information provided by one company which did not allow a plant visit is the basis for estimating the quantities of process wastes generated by the electronic components manufacturing industry.

In many instances particular wastes in individual plants were unquantifiable. Except for wastes which have recovery value, require specialized handling or are generated in some known proportion to raw material usage, reliable records of waste quantities are not kept. In a few instances, particularly in large, highly integrated plants, attempts to allocate known plant-wide waste quantities to the product area under study would have required more effort than the companies were willing to contribute. Nevertheless, a substantial amount of reliable plant data was obtained for each of the waste streams recognized for the industry.

Data was provided in a variety of units depending upon the nature of available written records, nature of the waste, or the rationale used by the company representatives in estimating the amounts of waste. These values were converted to kilograms of waste generated per year using appropriate conversion factors. Many of the wastes were liquid. Usually the density of the waste itself was not available. In such cases, the densities of the major raw materials and approximate proportions of those materials in the waste were used for the conversion.

The specific gravities assumed for various wastes were:

| | Specific Gravity | |
|---|---|---|
| **Halogenated Solvents** | Kg/L. | lbs/gal. |
| Perchloroethylene | 1.45 | 12.1 |
| Trichloroethylene | 1.45 | 12.1 |
| Freon | 1.45 | 12.1 |
| Halogenated Solvent Sludges | 1.75-2.0 | 14.6-16.7 |
| Methylene Chloride | 1.3 | 10.8 |
| **Non-Halogenated Solvents** | | |
| Isopropyl Alcohol | .9 | 7.5 |
| Methanol | .9 | 7.5 |
| Acetone | .9 | 7.5 |
| Mixed solvents | .9-1.4 | 7.5-11.7 |
| Xylene | .82 | 6.8 |
| Non-halogenated Solvent Slurries | 1.0-1.3 | 8.3-10.8 |
| Stoddard Solvent | 1.5 | 12.5 |

| | Specific Gravity Kg/L. | Specific Gravity lbs/gal. |
|---|---|---|
| Wastewater Treatment Sludges | | |

Calculated from solids content and specific gravity of solids. The specific gravity of sludge solids assumed to be 1.8 (= 15 lbs/gallon).

| | | |
|---|---|---|
| Hydraulic and Lubricating Oils | .9 | 7.5 |
| Paint Wastes | 1.5 | 12.5 |

For the purpose of extrapolating plant waste data to industry estimates, data on value of plant or product area shipments was requested. Where this was not made available, the number of either production or total employees involved in manufacturing the product under study was provided.

All plant data collected has been recorded on plant survey reports such as the one reproduced in Appendix C. Copies of the completed reports are maintained by EPA. Due to nearly universal company requests for confidentiality of this information, none of the plant information is reported here in such a manner that it can be attributed to any one company.

## Total Waste Generated

The method for extrapolating plant waste data to industry waste stream estimates included the following steps using hypothetical plant data to illustrate the steps.

1. Annual waste generation estimates for each process waste in any one plant was converted to pounds per year (lb/yr) as mentioned above. Each waste was categorized by waste stream. For the example, assume that the following wastes were generated from two plants in SIC 3677 and 36790 31:

| Waste Stream | Plant Waste Generation Rate (lbs/yr) Plant #1 SIC 3677 | Plant #2 SIC 36790 31 |
|---|---|---|
| Halogenated Solvents | 10,000 | 5,000 |
| Non-Halogenated Solvents | 15,000 | 2,000 |
| Wastewater Treatment Sludges | 0 | 10,000 |
| Hydraulic and Lubricating Oils | 100 | 500 |
| Plastics | 0 | 1,000 |
| Paint Wastes | 200 | 400 |
| Metal Scrap | 0 | 0 |
| Concentrated Cyanides | 0 | 0 |
| Concentrated Acids & Alkalies | 0 | 0 |

2. The plant waste stream generation rates were extrapolated to nationwide waste stream generation rates for that product area (SIC) using value of product shipment data if such was available for the plant. Alternatively, manufacturing or total employee data was used for the extrapolation. Each plant was thereby found to represent a percentage of the national production for its product area (SIC). Except for SIC 3679, the industry value of product shipments (1975) data [10] or employment (1972) data [5] was taken at the 4-digit level (3672, 3673, etc.). For SIC 3679 plant product areas were taken as 6- or 7-digit SIC's because of product diversity within 3679. Value of shipments and employment data for these product areas are available only for 1972 [5]. The ratio of the nationwide statistic (value of shipments or employment) to the plant statistic was then multiplied by the waste generation rates for each waste stream present.

Assuming for our example that plant #1 (SIC 3677) could not release value of shipments data but did report that they had an average of 120 production employees, the ratio used to extrapolate their waste generation data would be:

$$\frac{\text{1972 production employees for SIC 3677}}{\text{Plant \#1 production employees}} = \frac{19{,}100}{120} = 159$$

Similarly for Plant #2 for which product value of shipments was available:

$$\frac{\text{1972 value of product shipments, SIC 3679 31}}{\text{Plant \#2 value of product shipments}} = \frac{\$38.7\text{ million}}{\$1.2\text{ million}} = 32.2$$

Multiplying these factors by the plant waste generation rates in our example would yield product area waste generation rates:

| | Product Area Waste Generation Rate (lbs/year) | |
|---|---|---|
| Waste Stream | SIC 3677 | SIC 36790 31 |
| Halogenated Solvents | 1,590,000 | 161,000 |
| Non-halogenated Solvents | 2,385,000 | 64,400 |
| Wastewater Treatment Sludges | 0 | 322,000 |
| Hydraulic and Lubricating Oils | 15,900 | 16,100 |
| Plastics | 0 | 32,200 |
| Paint Wastes | 31,800 | 12,880 |
| Metal Scrap | 0 | 0 |
| Concentrated Cyanides | 0 | 0 |
| Concentrated Acids and Alkalies | 0 | 0 |

3. Not all of the product areas surveyed were represented by a single plant as in the example. Also, plant waste generation rates were not always quantifiable for some plant process wastes although the plant survey showed the presence of the waste. Waste generation rates for similar wastes from multiple plants within the same product area were added together and multiplied

by a product area: plant ratio calculated with the sum of the plant value of shipments (or employee numbers converted to plant value of shipments per Table II-7) instead of single-plant statistics. Where no wastes in a particular waste stream were generated by one of the plants, a zero was added into the overall waste generation rate for the multiple plants. If a waste was produced in one of the plants but its generation rate was not quantifiable, a side calculation was performed for other plants in the product area for which the waste type was quantifiable. The average waste generation rate in pounds per million dollars of value of product shipments was multiplied by the subject plant's value of product shipments to estimate the plant's waste generation rate.

4. The 23 surveyed plants represented eleven different product areas. For each of these eleven product areas waste generation rates in pounds per year for the nine process waste categories were projected as described above. Because many of the waste generation rates could reveal confidential information about specific plants, they are not presented here by process area. The waste generation rates were summed by waste stream across product areas to yield SIC 367 waste stream quantities. Three of the waste stream quantities were based on only one plant's waste generation rate. These waste streams were concentrated cyanides, concentrated acids and alkalies and beryllium wastes from the metal scrap process waste category. For reasons discussed at length earlier, the quantification of these three waste streams ceased at this point. Because the quantities for these waste streams were very small when extrapolated to the SIC 367 level, they were dropped from the total waste stream calculation also.

5. Of the six remaining waste streams, two typically contained significant percentages of water: wastewater treatment sludges and oils. The average solids concentration of the wastewater treatment sludges waste stream (percent dry weight) was determined from laboratory analysis of samples and information provided by surveyed plants. This average was weighted by the volumes of these sludges as scaled up to product area values. Average solids concentration of the sludges was determined by this method to be 20 percent. The remainder of this waste stream is considered to be water since very small volumes of materials such as solvents and oils (which would volatilize during the solids test) were present in the sludge waste stream. In contrast to the sludges, the oil waste stream data on percent water was meager. Due to the extensive use of water soluble cutting oils, the largest volume waste in the oil waste stream, the water content is estimated to be ninety percent. Total waste volumes for these two waste streams are, therefore, expressed in terms of both wet and dry weight. For other waste streams the water content is estimated to be very small so that wet and dry weights are reported to be the same.

6. The eleven product areas represented by the 23 surveyed plants cover 65 percent of the electronic components manufacturing industry. The dry and wet weights of each waste stream were, therefore, multiplied by 100%/65% = 1.54 to estimate the industry-wide quantities for each waste stream. The assumption implicit in this step is that the major process waste categories of the unsurveyed portion of the industry will be similar in type and generation rate (per million dollars of value of product shipments)

to the surveyed portion.

7. To this point all quantities were expressed in pounds per year. These figures were converted to kilokilograms per year (kkg/yr) by dividing by 2205.

## Quantification of Potentially Hazardous Wastes and Hazardous Constituents of the Waste Stream

The nature and hazardous constituents of the waste streams have been discussed above. The proportion of the waste streams considered hazardous, and the basis for estimating quantities of the hazardous constituents of the waste streams are briefly summarized below by waste stream.

Halogenated Solvents - Based on the fact that two out of the five solvent samples (halogenated and non-halogenated) collected in the surveyed plants had leachable, heavy metals in concentrations exceeding the relevant criteria for toxicity or bioaccumulation, two-fifths of this waste stream is estimated to be potentially hazardous.

Quantification of heavy metals as a hazardous constituent of the solvent waste streams is hindered by the availability of data. Five waste solvent samples (two halogenated, one mixed, and two non-halogenated) were collected and analyzed for this study. Water leachable heavy metals concentrations in these samples ranged from 0.25 mg/kg to 11.9 mg/kg (cadmium, chromium lead, and zinc). A value of 4.3 mg/kg is used here to estimate the concentration of leachable, heavy metals in the halogenated solvent waste stream.

Oils are also present in the halogenated solvents wastes. It is estimated that roughly 100 mg/kg oil is present in the two-fifths of the waste stream that has been used enough times to pick up significant heavy metals concentrations.

Non-halogenated Solvents - Using the same rationale as developed for the halogenated solvents, approximately two-fifths of this waste stream has seen sufficient use to have picked up significant concentrations of heavy metals and oils.

In addition to the presence of oils and heavy metals, the entire waste stream is estimated to be flammable, i.e., has a flash point below 100°F (32°C) and is, therefore, potentially hazardous.

Wastewater Treatment Sludges - All of these wastes contain either heavy metals or fluorides or both in significant concentrations. At the pH of the sludges, above pH 8, the fluorides are soluble in concentrations above the National Interim Primary Drinking Water Regulation Standards while the heavy metals are not, based upon leachate tests on samples. Heavy metals and fluorides are both expected to be leached from the sludges over long periods. Rate of leaching and concentration of these constituents in leachate will be dependent upon the amount and acidity of local groundwater. The entire waste stream is considered potentially hazardous due to the presence and probable release to the environment of heavy metals and fluorides.

The combined average concentration of lead, cadmium and chromium in sludge, for which detailed analysis is available, is 880 mg/kg expressed as a part of of the sludge dry weight. The amount of fluorides in sludges was derived from data on hydrofluoric acid usage in several plants. These calculations assumed that one hundred percent of the 70 percent hydrofluoric acid consumed would be converted to insoluble fluorides at elevated pH's. While this removal efficiency is not achievable, it is a reasonably close approximation. Analytical results provided by one company of the fluoride in their sludge are in agreement with the results obtained by this method.

Plastics - No hazardous constituents have been recognized in this waste stream.

Oils - Oils present as part or as the major constituent of cutting, hydraulic and lapping oils renders all of these wastes in this waste stream hazardous. Due to the high proportion of water soluble cutting oils in this waste stream, the average concentration of oils in the waste stream is estimated to be five percent, although specific wastes are nearly 100 percent oil.

Based upon analysis of two lapping oil wastes, the combined average concentration for lead, chromium, and cadmium in this waste stream is 2600 mg/kg as a part of the dry weight.

Paint Wastes - The wide-spread use of lead and chromium in formulating paints results in nearly universal heavy metals contamination of this waste stream. Based upon the analysis of two paint waste samples, the average lead plus chromium concentration in paint wastes is estimated to be 260 mg/kg dry weight. The ability of these metals to leach into water from solvent-containing paint wastes appears from limited data to be dependent upon pH. The effects of the presence of solvents in paint wastes on metal solubility has not been analyzed for this study, but such information would be relevant to assessing the potential hazard of such paint wastes as dry booth filters on which atomized paint has dried.

Also present in some of the wastes in this waste stream are flammable, non-halogenated solvents used in paint equipment clean up. It is estimated that fifty percent of the paint waste stream is flammable, non-halogenated solvents.

## Projected Changes in Waste Generation

With the exception of the wastewater treatment sludge waste stream, effluent guidelines for wastewater discharges are not expected to have a significant impact on quantities of the significant waste streams generated by the electronic components manufacturing industry in the future.

The 1977 and 1983 quantities of the six major waste streams were increased in proportion to the changes in product area value of shipments presented in Table II-10. The ratios of 1977 and 1983 value of industry shipments are listed in Table III-16. With the exception of the wastewater treatment sludge waste stream these ratios were multiplied by the waste stream volumes calculated for each product area as described above. The proportions of potentially hazardous wastes and hazardous constituents were calculated from the 1977 and 1983 waste stream totals in the manner described above for the 1975 waste stream quantities.

The calculations of future waste volumes are consistent with the assumption used throughout this report that wastes generated within each product area are proportional to production as described by value of shipments. The use of value of industry shipments in some steps of the calculations and value of product shipments results in some inconsistencies since the values are not strictly comparable. However, the error created is considered to be much smaller than that caused by the accuracy of basic waste data obtained from the plants and by the relatively small number of plants visited, less than one percent of the national total. The use of both indexes of production is necessitated by the failure of available information sources to provide consistently applicable figures at the four-digit SIC level in terms of either one of the indexes.

### Effects of Public Law 92-500 on the Wastewater Treatment Sludge Waste Stream

Sections 301, 304(b), and 306 of the 1972 Amendments to the Federal Water Pollution Control Act call for implementation of effluent limitations, standards of performance and pretreatment standards for point sources other than publicly owned treatment works. Two levels of wastewater treatment technology are to be implemented, the earliest by July 1, 1977 and the other by July 1, 1983. The 1977 technology level involves application of the best practicable control technology currently available (BPT). The 1983 technology level is based on the best available technology economically achievable (BAT) and has the goal of eliminating the discharge of all water pollutants.

Effluent limitations and performance standards for the electronic components manufacturing industry are proposed in three applicable documents: "Development Document for Effluent Limitations Guidelines and Standards of Performance for the Machinery and Mechanical Products Manufacturing Point Source Category" [7], "Development Document for Proposed Effluent Limitations Guidelines and New Source Performance Standards - Copper, Nickel, Chromium and Zinc Segment of the Electroplating Point Source Category" [8], and "Development Document for Interim Final Effluent Limitations Guidelines and Proposed Finishing Segment of the Electroplating Point Source Category" [9].

Three categories of industrial point sources are covered by these development documents: existing plants with direct discharge to navigable waters, new plants with direct discharge to navigable waters, and both old and new plants which discharge to municipal wastewater treatment works.

While the requirements for BPT and BAT differ slightly between the three development documents for these point source categories (pretreatment standards and technology for plants that discharge to municipal works, for

## TABLE III-16

### Ratios of 1977 and 1983 Value of Industry Shipments to 1975 Value of Industry Shipments(a)

| SIC | 1977 | 1983 |
|---|---|---|
| 3672 | 1.222 | 1.620 |
| 3673 | 1.236 | 1.712 |
| 3674 | 1.250 | 1.769 |
| 3675 | 1.188 | 1.442 |
| 3676 | 1.132 | 1.139 |
| 3677 | 1.244 | 1.733 |
| 3678 | 1.250 | 1.769 |
| 3679 | 1.226 | 1.642 |

(a) - Calculated from estimates presented in Table II-10.

instance, are covered only by the machinery and mechanical products document), BPT for 1977 will be achieved by cyanide oxidation, hexavalent chromium reduction to the trivalent form, neutralization, and coprecipitation of metals as hydroxides at elevated pH. Coprecipitation of the metals produces a sludge with one to two percent solids. This sludge is lagooned in sealed ponds or concentrated by various methods to solids concentrations as high as 40 percent prior to land disposal. Recovery of metals from coprecipitation sludges is rarely practicable [9].

BAT for all three documents involves no discharge of pollutants from processes used in the electronic components manufacturing industry. Achievement of BAT in 1983 for existing sources and in 1977 for some new sources [7] is expected to require in-plant control of pollutant discharge, chemical treatment of wastewater as for BPT, and 100 percent water reclamation and reuse. The documents recognize that the achievement of no-discharge may be feasible by methods other than those suggested.

Pretreatment standards for both technology levels at this time are still in the process of review [35]. Uncertainty exists about what effect the type of local municipal treatment provided will have on these standards. For instance, if a municipal treatment plant is required to remove phosphorus from the effluent because of nutrient problems in the receiving waters, lime or alum flocculation and sedimentation will likely remove some of the heavy metals and fluorides discharged by electronic component manufacturing plants. In such cases, the yet-to-be-issued pretreatment guidelines may remove the requirement for pretreatment at small plants, thereby reducing or eliminating the amount of sludge generated at the electronic components plant itself. Applicable pretreatment standards are currently being formulated and, so, are not available for predicting their impact on sludge generation.

Because the impacts of new treatment technology and revised pretreatment requirements cannot be practiced, it is assumed for the purpose of estimating future sludge production from the industry that BPT technology will be utilized in all electronic components plants by 1977.

Coprecipitation sludges will, by this assumption, be generated by all plants with heavy metals in their wastewater. While the development documents are not specific in regard to recommended methods for the removal of fluoride, it is assumed here that its precipitation with lime will be required in all plants where it is currently discharged.

1975 generation of wastewater pretreatment sludges is estimated by applying the previously described procedure used for all waste streams. A sufficient amount of data was available to estimate sludge generation for each product area.

Estimates for 1977 generation of wastewater treatment sludges are based on the assumption that all plants which have manufacturing processes generating heavy metal and/or fluoride water carried wastes will generate sludges in the same proportion to production (value of shipments) as plants in similar product areas already generating sludges. Average solids concentration (dry weight), metal concentration, and fluoride concentration in the sludges is assumed to be the same as in sludges found in surveyed plants.

The development documents [7,8,9] predict that the incremental increase in sludge generation caused by the no-discharge technology suggested for 1983 will be small. Recovery of water by reverse osmosis and evaporation of the reverse osmosis brine is expected to add a comparatively small volume of soluble salts to the wastewater treatment sludge waste stream. This volume is considered to be negligible for the purposes of estimating 1983 sludge generation.

In-plant water and pollution control measures may ultimately result in wide-spread use of contractor removal of concentrate cyanide, metal and acid and alkali solutions for land disposal. This is currently practiced by at least one electronic components manufacturing plant. Disposal of hazardous pollutants by this method may aid plants in meeting the 1985 BAT requirements but will have the effect of creating larger volumes of waste for land disposal. Possible economic advantages of land disposal of concentrated wastewaters will likely be influenced by a number of considerations such as proximity of suitable land disposal sites, the cost of land disposal (which will be directly affected by land disposal regulations), and costs for both existing and future alternative treatment technologies. For the purposes of estimating concentrated cyanides, acids, alkalies and wastewater treatment brines waste streams generated by the electronic components manufacturing industry, it is assumed that the quantity will remain at the negligible levels suggested by plant survey data.

## SUMMARY OF THE WASTE STREAM QUANTIFICATIONS

Process wastes of the electronic components manufacturing industry have been grouped according to their origin and major constituent into ten waste categories. On the basis of their final disposal in significant quantities to the land, six of these waste categories are defined for this report as "waste streams" of the industry. These waste streams have been quantified for 1975 in terms of metric tons generated per year and projections of their volumes for 1977 and 1983 by methods described in the report. Four wastes, beryllium clean-up materials, concentrated cyanides, concentrated acid and alkalies, and a polychlorinated biphenol waste, are considered to be potentially hazardous but have not been considered as waste streams and are not quantified here because they either are not generated in significant quantities or are not typically land disposed as generated by the industry.

Results of the waste stream quantifications are presented in three sections of this report. Total waste stream volumes, total potentially hazardous waste stream volumes and total hazardous constituents are reported for 1975, 1977 and 1983 in Tables I-1, I-2, and I-3. National, state and EPA Region volumes are reported in those tables for all waste streams and constitutents without identifying the waste streams of origin. National volumes of the individual waste streams, their potentially hazardous wastes and hazardous constituents for 1975, 1977 and 1983 are presented in Tables III-1, III-2, and III-3. Disaggregation of the national volumes are presented in Appendix B. Allocation of the national figures to the states was performed using the value of industry shipments reported in Table II-8. Adjustments to that data were made to account for value of shipments not reported by state. Unreported four-digit SIC value of shipments were divided evenly among states which had plants but for which values were not reported (designated "(D)" in Table II-8). These figures were added to the reported state totals and divided by the national total value of shipments for SIC 367. The state ratios were multiplied by the various national waste volumes to determine state volumes. State volumes were added by EPA Region to determing EPA Regional values.

# SECTION IV

# TREATMENT AND DISPOSAL TECHNOLOGY

## INTRODUCTION

This section describes the treatment and disposal technology utilized by the electronic components manufacturing industries. Except for organic solvent reclamation, on and off site, by some plants, there is little treatment of potentially hazardous wastes prior to disposal. Concentration of wastewater treatment sludges, considered here as waste treatment process, is practiced in a few plants. Most of the wastewater treatment sludges, lubricating and hydrualic oils, and paint wastes are all disposed of in landfills without prior treatment.

Because of their liquid state, most of the wastes are drummed for transportation to landfill or reclamation sites. Virtually all of the potentially hazardous waste destined for off-site disposal or reclamation is handled by private contractor. Contact was made with reclaiming operations and landfill sites were visited to find out how the wastes were handled and ultimately disposed of.

Three levels of technology are indicated in this section for each potentially hazardous waste. Level I is the most prevalent technology; Level II is the best method presently used which is amenable to more widespread use; and Level III is the technology which is most adequate from an environmental and public health perspective.

There are differences between individual plants in handling and disposing of the wastes related to quantities generated, economics, and attitude towards waste disposal. In general electronic component manufactures pay very close attention to manufacturing processes to maintain high product quality. This includes careful in-plant handling of all wastes so that final product quality is not adversely affected by in-plant waste handling methods.

With the exception of water-carried wastes, little future change is expected in the waste disposal and treatment technology of these industries. However, within SIC 3674 -- Semiconductor Manufacturing, new products quickly develop to replace old ones and this could lead to changes in waste quantities, treatment and disposal technology in the second largest four-digit SIC classification in this industry.

Definition which apply to the technologies discussed here are as follows:

Landfill - Land disposal facilities characterized by their acceptance of a wide variety of wastes including garbage which are compacted in layers and covered daily. They do not normally have special containment, monitoring, or provision for treatment of leachate. Some have liquid waste disposal facilities separate from solid waste disposal.

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Secured Landfill - Land disposal facilities characterized by impervious containment of the waste with provisions for monitoring and treatment of leachate if required. Adequate diversion and control of surface water are required as well as registration of the site for a permanent record of its location once filled,

Incineration - Combustion of an organic or partially organic waste stream with adequate means for complying with applicable air pollution control regulations and for disposal of collected particulates and ash (usually of a potentially hazardous nature) in a secured landfill.

Reclamation - Processes used to turn a process waste into a usable raw material for electronic component manufacturing and/or other industries.

## DESCRIPTION OF PRESENT WASTE HANDLING AND TREATMENT TECHNOLOGY

With few exceptions the surveyed plants were well organized and maintained in an unusually dust and litter-free condition. Standards of plant cleanliness are high to minimize the potential for contamination of incomplete components. In accord with the high cleanliness standards, most process wastes are collected as they are generated. Separate storage of process wastes outside of production areas is common practice for most plants.

Organic solvents and wastewater treatment sludges are the most frequently treated potentially hazardous waste, although they are by no means treated in all plants. Lubricating and hydraulic oils and paint wastes are not generally treated in these plants because of the small quantities generated.

Both the halogenated and non-halogenated solvents are carefully handled to avoid spills of these expensive and reclaimable materials and to prevent dangerous accidents that could result from their toxicity and flammability. Halogenated solvents are twice as expensive as nonhalogenated solvents and are often reclaimed in-plant by a batch distillation process explained below. Solvent wastes removed from the plants range in amount of impurities from the still bottoms of in-plant halogenated solvent reclamation to solvents clean enough for resale without further processing. U.S. Department of Transportation shipping regulations [36] require that the flammable wastes be properly containerized and labeled for transportation.

The most common waste treatment technology recognized in the surveyed electronic components manufacturing plants was the reclamation of organic solvents. Eight of the fifteen plants that use organic solvents have these solvents reclaimed, either off-site by a private contractor or on-site reclamation facilities. Based on the plant survey data 59 percent of the halogenated solvent wastes and 50 percent of the nonhalogenated wastes are segregated for reclamation.

Solvents reclamation techniques range from repacking where clean solvents are disposed of to distillation and fractionation where separation of mixed solvents is required. Many of the solvents disposed of by plants in SIC 367 are clean enough to be reused for other industrial purposes with little or no treatment being required. One private contractor simply repackaged the waste solvent in smaller volumes before selling it to other customers. Private contractors that process large quantities of organic solvents from many different industries generally distill solvents for reclamation.

The type of on-site reclamation facilities is generally a function of plant size. The large plants which have on-site reclamation facilities tend to have separate distillation facilities for solvent reclamation. One large plant used a fixed-bed carbon adsorption process for solvent reclamation. Smaller plants which reclaim solvents on-site use a batch distillation system built into the process equipment for reclamation of halogenated solvents. The batch distillation process observed in plant surveys involves heating up the halogenated solvent contained in vapor degreasing tanks. Upon heating, the halogenated solvent is evaporated and the condensate is collected and siphoned into another vessel. The remaining unevaporated still bottoms are disposed on-site, drummed for landfill, or shipped in containers to off-site reclamation facilities. The halogenated solvent is then returned to the cleaned tanks for reuse once the still bottoms are removed.

Use of reclaimed organic solvents where feasible is usually more economical than purchasing unused solvents. For organic solvent quantities of less than four drums, reclamation costs range from 25 percent to 40 percent of the cost of purchasing unused solvents when the efficiency of reclamation ranges from 90 percent to 20 percent. For organic solvent quantities of greater than four drums, reclamation costs range from 18 percent to 30 percent of the cost of unused solvents when the efficiency of reclamation ranges from 90 percent to 20 percent [26].

In spite of the attractive economics of solvent reclamation, most electronic component manufacturers do not reclaim all organic solvents. Most plants reclaim the more expensive halogenated solvents by an on-site batch distillation process, but many small plants find it more economical, because of location and transportation costs, to dispose of small quantities of used organic solvents without reclamation. Some plants will purchase back reclaimed solvents. However, most plants require unreclaimed solvents because product quality demands ultraclean surfaces where surface contamination can alter the electronic properties of components.

Depending on the suspended solids and heavy metals content of contact process waters, some wastewaters are treated before discharge into the sanitary sewer. Thirteen of the surveyed plants treated their wastewater before discharge into sanitary sewers. Nine of these thirteen used physical/chemical treatment methods such as chemical precipitation with sedimentation, or in a few instances just sedimentation, thereby generating a sludge for disposal. Four of these nine plants indicated that the wastewater sludges are concentrated by centrifugation or pressure filtration. One plant placed its sludge in an on-site lagoon where the water is allowed to evaporate before the sludge is pumped out and transported off-site for final disposal at an unknown site.

Centrifugation is a process whereby sludge is fed into a rotating bowl at a constant flow rate where it separates into a dense cake with a solids concentration ranging from 15-40 percent and a dilute stream called centrate. Centrate is usually recycled through the wastewater treatment plant. Pressure filtration is a process whereby sludge is pumped in between two plates to which pressure is applied. The pressure forces the water through filter cloth, which is fitted over the plates, and through the plate openings producing a filter cake with a solids concentration ranging from 35-40 percent.

Sludges generated in the treatment processes observed in the plant visits vary from being 0.25 percent to 97 percent solids. This range is due to the many different processes and materials used in electronic component manufacturing. The sludges are either drummed, placed in the dumpsters or piped into speical tank trucks for transportation typically to off-site landfill disposal. The sludges are drummed for disposal when relatively small quantities are generated. Large quantities of liquid sludge are held in tanks and are more economically transported by special tank trucks. Highly concentrated sludges, such as those produced by pressure filtration and centrifugation, are sometimes stored in a dumpster set aside for sludges only.

Handling of the wastewater sludges in electronic component manufacturing depends on the amount of sludge generated. In the plants that generate large quantities of sludge, it is usually more economical, because of transportation and disposal costs, to reduce the volume of the wastewater sludges before final disposal. Some plants located in urban environments may also find sludge treatment economical when nearby landfill disposal sites are not available.

Lubricating and hydraulic oils are not usually treated before disposal because of the small quantities generated. Separated lubricating and hydraulic oils inlcude both water-based coolants and petroleum distillate oils. Two plants indicated that the petroleum distillate oils were recycled. One plant filtered the oil and recycled it while the other recycled the oil after sedimentation. In the second plant the unfiltered residue and sediment is drummed for final disposal. Water-based coolants which are too dirty for continued use are usually disposed of without reclamation.

Many plants use small quantities of oils which are disposed of without recycling. When small quantities are generated, the waste oils are mixed in with the general solid waste in the dumpster for disposal. In one plant the lubricating and hydraulic oils were combined with the wastewater and unreclaimed solvents for handling by the wastewater treatment plant and, in another the oil was dumped on-site. In plants where large quantities are generated, waste oils are usually separately drummed for disposal.

Paint wastes are also not usually treated before disposal because of the small quantities generated. Paint wastes consist of spent dry filters containing paint residue and waste paint cleaned up with rags and solvents. Paint wastes are often thrown in the dumpster along with other general industrial solids wastes for disposal. In unusual situations where large dip tanks are cleaned or large quantities of paint wastes are disposed of, the wastes are usually separately drummed for disposal.

## DESCRIPTION OF PRESENT TREATMENT AND DISPOSAL TECHNOLOGY

A wide range of treatment and disposal technologies are practiced in the electronics components manufacturing industries. Waste disposal technology varies between plants due to factors of size, economics and attitude towards waste disposal. In general the larger plants apply more sophisticated technology to waste disposal. Waste disposal technology for potentially hazardous wastes ranges from on-site surface dumping to controlled incineration with disposal of residue in a landfill.

Segregation of potentially hazardous wastes for storage and disposal is typical in surveyed plants. Segregation of potentially hazardous wastes is practiced in plants which generate large quantities of waste, in plants where some of the wastes are reclaimed or recycled, and in plants that have very strict waste handling procedures. In some of the plants where potentially hazardous wastes are shipped off-site for reclamation and disposal; segregation, labeling and handling of the wastes are done according to Department of Transportation Specifications [36]. Organic solvents are segregated from other potentially hazardous wastes because they are either destined for reclamation or considered more dangerous due to toxicity or flammability.

Most of the unreclaimed halogenated and nonhalogenated waste solvents are landfilled or incinerated. Small volumes of still-bottom sludges and unreclaimed solvents are sometimes dumped on the plant grounds.

Six of the surveyed plants dispose of unreclaimed, nonhalogenated solvents and halogenated solvent still bottoms in a landfill. Three of these plants indicated that disposal was in a secured landfill. Four of the plants incinerated some unreclaimed solvent wastes. Four plants dumped small quantities of still bottom sludges or unreclaimed nonhalogenated solvents on the plant grounds and three plants discharged small quantities of nonhalogenated solvents in the sanitary sewer.

Organic solvents and unreclaimed still bottoms that are disposed of in a sanitary landfill are usually not mixed in initially with the other dry solid waste but are placed in separate storage areas reserved for liquids. Small quantities, ranging from .09 kkg/year to 6 kkg/year, of halogenated and nonhalogenated solvents are dumped on-site. Some company spokesmen indicated that the reason for on-site dumping and sewering small quantities of waste organic solvents is that such small quantities did not cause any environmental harm and need not be disposed of in another way.

Only large plants among those surveyed incinerated waste solvents. Two plants have on-site incineration facilities. For plants located in urban environments where nearby landfill sites are not available, incineration may be economically more attractive than landfill disposal for potentially hazardous wastes.

Wastewater treatment sludges, generated separately from other potentially hazardous wastes, are usually kept segregated during storage and disposal. Most of the surveyed plants use private contractors to dispose of the wastewater treatment sludges in a landfill. Two plants indicated that disposal of the wastewater treatment sludges are in a secured landfill. Two other plants indicated that the sludges were incinerated with disposal of final residue in a landfill. Wastewater treatment sludges disposed in a landfill are usually placed apart from municipal solid wastes and are often mixed with liquid wastes.

Lubricating and hydraulic oils are not necessarily segregated from other wastes for storage and disposal. Petroleum distillate oils where used in large quantities, may be segregated from other wastes for reclamation. Except for reclamation of petroleum distillate oils, most of the lubricating and hydraulic oils are disposed of by private contractor in a landfill. Petroleum distillate oils deemed too dirty for reclamation and the residue from recylcing operations are also placed in a landfill. One plant indicated that oils not recycled were incinerated. This particular plant mixed all chemical wastes together and transported them by private contractor off-site for incineration. Another plant practiced on-site disposal of water soluble coolant oils by dumping on the plant grounds. Where small quantities are generated, the waste oil is sometimes either mixed with the plant solid waste or dumped on the plant property. Most plants using small quantities of lubricating and hydrualic oils, however, dispose of the waste in off-site landfills without reclamation. Company spokesmen indicated that the economics of reclamation only become attractive when large quantities of petroleum distillate oils are used. No reclamation of water soluble cutting oils was recognized except for the common practice of sedimentation or filtration in-plant.

Paint wastes are not usually segregated from other wastes for storage and disposal unless large quantities are generated. Contractor disposal in a landfill along with other plant trash from dumpsters is the most common method of paint waste disposal. There is no recycling of paint waste indicated by the plant visits. Most painting operations used dry booths or hand painting operations. In some plants disposal of dry spray booth filters is done with the general plant solid waste which is placed in a landfill along with small quantities of paint clean-up materials including solvents and wet rages. One plant placed small quantities of solvent-based lacquer clean-up waste in an on-site lagoon along with wastewater treatment sludges.

In plants where large quantities of solvent-based paint waste are generated, paint waste are separately drummed for landfill.

## ON-SITE VS. OFF-SITE TREATMENT AND DISPOSAL

Treatment of potentially hazardous wastes generated by surveyed plants is generally limited to the organic solvents and wastewater treatment sludges. Some petroleum distillate oils and solvent-based paint wastes from the plants were reclaimed in off-site facilities but the number of occurrences of this practice and the volumes involved were small in comparison to the entire waste streams.

As has been previously described, in-plant halogenated solvent reclamation is a common practice. The lack of a flash point in these solvents and the high cost of new solvents makes this practice attractive to both large and small plants. Off-site reclamation of approximately half of both the halogenated and nonhalogenated solvent waste streams is suggested by survey data. On-site distillation of nonhalogenated solvents was not practiced in any of the surveyed plants, apparently because of relatively low replacement cost and the substantial risk of fire or explosion during the process.

When wastewater treatment sludges are concentrated prior to disposal, it is done on-site in proximity to the wastewater treatment facilities to minimize transportation costs. Of the eight surveyed plants generating these sludges, two concentrated the sludges in lagoons, two centrifuged them and two used filter presses.

Thirteen percent of the potentially hazardous wastes quantified for the surveyed plants were disposed of on-site. Individual plant wastes disposed of on-site ranged in volume from halogenated solvent sludges and nonhalogenated solvents surface dumped a few gallons at a time at four plants to wastewater treatment sludges from a large plant held indefinitely in an on-site lagoon. Another high volume waste, a water-soluble cutting oil, is surface dumped at a different plant. On-site incineration of paint wastes is practiced at one plant.

On-site disposal of small volume wastes from small plants is likely more common than indicated by the plant survey data. Small plants, in lieu of regulations to the contrary, generally will not commit the attention and resources necessary to find adequate disposal methods for their potentially hazardous wastes. As explained in the next section, personnel in the small plants do not view the small volumes of waste whcih they generate as a source of danger.

## PRIVATE CONTRACTORS AND SERVICE ORGANIZATIONS

It was specifically reported in only one instance that a plant's own trucks haul some of their potentially hazardous wastes to a disposal site. It is understood that some components manufactures make occasional and unscheduled trips to haul nonhazardous trash to a municipal disposal area, but it was not suggested that these loads contain the wastes defined as hazardous in this report with any frequency. Thus, although the plant surveys were very limited in number, it is felt that they establish the fact that the majority of the wastes generated by SIC 367 plants are carried away from the plant by private contractors.

A list of 49 contractors reported by the plants visited is shown in Appendix D. Their methods and capabilities vary quite widely. The final disposal method of four private contractors is listed as "unknown" since ultimate disposition could not be identified by plant personnel and the contractors could not be contacted and do not appear on recent EPA lists of disposal contractors. Due to their local character, it is expected that these four contractors probably employ land disposal without reclamation or incineration.

Landfill disposal is listed for twelve operations and secured landfill disposal is listed for seven operators. Due to state and local regulations governing land disposal, none of the unsecured landfills are suspected of being "dumps."

Four of the contractors listed have incineration facilities; eight reclaim solvents and one reclaims oil; twelve others recover metals. Metal is generally reclaimed on an industry-wide basis and therefore has not been designated as a waste stream.

Seven disposal sites which serve SIC 367 plants were visited during the study. Five of these were on-site disposal sites. Two sites belonged to contractor organizations, one in Region IX and the other in Region IV.

One contractor disposal site was a sanitary landfill which disposed of liquid waste separately from solid waste. Liquid waste was disposed of here in drums in separate cells of a sanitary landfill. The company spokesman said that the purpose of separation was to minimize leaching in a landfill which may result if the drummed liquid and solid waste were disposed of together.

The other site was a secured landfill which had two separate disposal areas. One area contained drummed liquid wastes which is covered daily and the other was a lagoon. The drummed area contains toxic chemical wastes such as cyanides, and the lagoons contain other less toxic sludge-liquid wastes. In general, the wastes were separated to prevent chemical reaction between different wastes that might adversely affect operation and management of the secured landfill.

One other contractor, visited in a related industrial hazardous waste survey [33], disposes of wastes generated by one of the plants visited in SIC 367. The company disposes of organic chemical wastes through an incineration. The incineration equipment includes extensive air pollution control including two high-energy venturi scrubbers.

A good deal of information was obtained on the services of another more sophisticated disposal and recovery contractor in Region II through the survey of a large plant belonging to one of its customers. This contractor facility provides oxidation-reduction, acidulation, neutralization, chemical detoxification, chemical fixation, and thermal destruction of liquid wastes as well as oil and solvent recovery. Its fluidized bed incinerator is equipped with an alkaline gas scrubber. Final disposal of unreclaimed residue is in reinforced, membrane-lined, clay cells of a secured landfill with leachate collection and treatment. Analytical services are available to determine the appropriate methods and cost of disposal.

## WASTE GENERATION AND DISPOSAL TECHNOLOGY FOR AN AVERAGE PLANT

Process, product and waste diversity among the surveyed plants prohibits realistic description of raw material usage, process flow, or waste generation in terms of how a typical electronic components manufacturing plant operates. However, average waste generation figures can be calculated from the national figures on number of plants, value of shipments and waste stream totals presented elsewhere in this report. Typical present disposal technology for each waste stream is equivalent to Level I technology described under "Treatment and Disposal Technology." Relevant information is presented in Table IV-1 for the entire industry and for an average plant in terms of value of shipments, number of employees, annual waste stream volumes, and current disposal technology.

## SAFEGUARDS USED IN DISPOSAL

The degree of waste segregation, in-plant waste handling and storage, and disposal methods chosen by plant managers appears, from conversations with them, to be influenced by six factors: 1) value of the waste for reclamation, 2) hazards to plant personnel, 3) regulations governing disposal and transportation, 4) risk of lowering product quality, 5) amount of waste generated and 6) costs of handling and disposal. Environmental and public health considerations beyond compliance with regulations are a factor in waste handling and disposal decisions primarily in those companies large enough to commit personnel to perform evaluations of such risks for the company's specific wastes.

Value of wastes for reclamation is a determining factor in the disposition of metal wastes, halogenated solvents, nonhalogenated solvents and, to a limited degree, petroleum distillate oils. Some of the most rigorous precautions taken in the industry for waste reclamation apply to clean-up of precious metal wastes for obvious reasons. These wastes are a commodity for which contractors submit bids even to relatively small plants. Efforts expended to segregate and sell solvent and oil wastes are proportional to the amount and cleanliness of the waste. Some plants give these wastes to contractors, dispose of them on-site or even pay to have them taken away if the amounts generated are small. No wastewater sludges, plastics or paint wastes were reclaimed from surveyed plants.

Hazards to plant personnel from solvent wastes, cyanide solutions and beryllium wastes are well recognized. Occupational Safety and Health Administration regulations appear to have been particularly effective in educating industry personnel to the hazards posed by these materials. Storage of solvent wastes in outside enclosures is a universal practice. Segregation of cyanide wastewaters from possibly acidic solutions is in line with recognized engineering practice. Heroic measures are taken in one plant that cuts beryllium oxide stock, including work area ventilation, containerization of air filters, personnel clothing, lubricating solution, clean-up rags and floor sweepings, and long distance transportation to a secured landfill.

Department of Transportation regulations [36] promote segregation of flammable solvent wastes. State regulations governing disposal of hazardous wastes in California, Illinois, and Massachusetts do not directly affect company decisions about waste handling since all hazardous wastes generated by surveyed plants in these states are handled by private contractors.

### TABLE IV-1

### 1975 PLANT PRODUCTION, EMPLOYMENT, NUMBER OF PLANTS, WASTE STREAM GENERATION RATES AND LEVEL I DISPOSAL TECHNOLOGY FOR THE ELECTRONIC COMPONENTS MANUFACTURING INDUSTRY AND FOR AN AVERAGE PLANT

| | | INDUSTRY | AVERAGE PLANT | LEVEL I DISPOSAL TECHNOLOGY |
|---|---|---|---|---|
| Number of Plants | | 2,500[(a)] | 1 | |
| Total Employees | | 359,000[(a)] | 144 | |
| Production Employees | | 273,000[(a)] | 109 | |
| Value of Product Shipments ($ million) | | 10,115[(a)] | 4 | |
| Waste Streams [(b)] (kkg/yr) | | | | |
| Halogenated Solvents | (Dry wt.) | 10,780 | 4.3 | On- and off-site reclamation. Drummed still bottoms and unreclaimable solvents to landfill. |
| | (Wet wt.) | 10,780 | 4.3 | |
| Nonhalogenated Solvents | (Dry wt.) | 15,400 | 6.2 | Off-site reclamation. Drummed still bottoms and unreclaimable solvents to landfill. |
| | (Wet wt.) | 15,400 | 6.2 | |
| Wastewater Treatment Sludge | (Dry wt.) | 5,390 | 2.1 | Off-site landfill |
| | (Wet wt.) | 27,720 | 11.1 | |
| Hydraulic Lubricating Oils | (Dry wt.) | 185 | .07 | Off-site landfill |
| | (Wet wt.) | 1,540 | .61 | |
| Plastics | (Dry wt.) | 4,620 | 1.8 | Off-site landfill mixed with plant trash. |
| | (Wet wt.) | 4,620 | 1.8 | |
| Paint wastes | (Dry wt.) | 200 | .08 | Off-site landfill mixed with plant trash. |
| | (Wet wt.) | 200 | .08 | |
| TOTAL | (Dry wt.) | 36,575 | 14.6 | |
| | (Wet wt.) | 60,260 | 24.1 | |

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(a) Source: U.S. Industrial Outlook 1976 [10].

(b) See Table III-1.

Costs involved in disposal of hazardous wastes in these states have the effect of minimizing the mixing of hazardous with nonhazardous wastes, however. Air pollution regulations appear to have minimal impact on hazardous waste generation and disposal although reclamation of airborn solvents from magnetic recording tape manufacturing serves the dual purpose of reducing air emissions and recovering valuable solvents. Nationwide application of the concern about the photoreactivity of trichloroethylene, xylene, and toluene, as embodied in Los Angeles Rule 66 [29], may result in a reduction in their occurrence in the organic solvent waste streams.

Because product performance is a basis of competition in the industry, especially for manufactures of technologically mature components, and because sometimes minute amounts of contamination can detract from product performance, plant managers often pay considerable attention to in-plant control of wastes. The use of "white rooms" in several plants visited testify to this concern. Where plant cleanliness is of such concern, the degree of waste segregation and the attention paid to removing the wastes are high. A secondary result of this attention appears to be a better awareness of the ultimate fate of the wastes.

Where waste volumes are low, the economic incentives to give special handling to waste is naturally low also. In addition, there appears to be a correlation between the amount of waste material generated and the plant managers opinion about its hazardous nature. In part, this may be due to the amount of attention that personnel in small plants can afford to give such matters. As a result, only those wastes which present an in-plant danger, such as the organic solvents, are considered hazardous. Paint wastes and waste oils are often not considered hazardous at all. Safeguards chosen for the disposal of low volume wastes and wastes which do not immediately threaten personnel safety or product quality are often nonexistent.

## LEVELS OF TREATMENT AND DISPOSAL TECHNOLOGY FOR POTENTIALLY HAZARDOUS WASTE STREAMS

The U.S. Environmental Protection Agency has defined three levels of treatment and disposal technology which are or may be applicable to potentially hazardous waste streams generated by the industries which manufacture electronic components and are destined for land disposal. These technology levels are defined as follows:

LEVEL I - The technology currently employed by the majority of facilities -- i.e., broad average present treatment and disposal practice.

LEVEL II - The best technology currently employed. Identified technology at this level must represent the soundest process from an environmental and public health standpoint currently in use in at least one location. Installations must be commercial scale. Pilot and bench scale installations are not considered for this level.

LEVEL III - The technology necessary to provide adequate health and environmental protection. Level III technology may be more or less sophisticated or may be identical with Level I or Level II technology. At his level, identified technology may include pilot or bench scale processes providing the exact stage of development is identified.

There are five major waste streams in the manufacturing of electronic components that have been designated as potentially hazardous in Section III. Levels I, II, and III treatment and disposal technologies for halogenated solvents, nonhalogenated solvents, wastewater treatment sludges, hydraulic and lubricating oils and paint wastes are presented in Table IV-2 to IV-6.

The number of plants in the industry using each technology was estimated on the basis of survey data from 22 plants. This sample of establishments represents less than one percent of the number of electronic components plants but 3.6 percent of industry production.

The most prevalent current technology (Level I) for halogenated and nonhalogenated solvents is reclamation with disposal residuals in a landfill. Level II, the best technology currently in use, is the same as Level I for halogenated and nonhalogenated solvents except that the residual is disposed of in a secured landfill. For halogenated solvents Level III, environmentally adequate technology, is the same as Level II, assuming proper burial of the unreclaimable residue in the landfill. Proper burial separate from flammable materials and ashes is recommended to prevent combustion in proximity to the halogenated solvent residues which can result in the emission of poisonous gases. The flammability of nonhalogenated solvents required that Level III technology be reclamation of solvents with incineration of unreclaimable solvents and disposal of the incinerated ash and still bottoms in a secured landfill because of possible heavy metal constituents. Limited availability of adequate incinerators and secured landfills presently limits widespread use of Level II and Level III treatment and disposal technologies for halogenated and nonhalogenated solvents.

Contractor disposal in a landfill is Level I technology for wastewater treatment sludges, lubricating and hydraulic oils, and paint wastes. Except for a small amount of on-site dumping on the plant grounds and incineration by some plants, this technology is almost universally applied in the industry.

Level II technology for wastewater treatment sludges is on-site dewatering and secured landfill disposal. Reduction in sludge volume by various dewatering methods will preserve space in secured landfills and reduce the amount of free water present. Level III technology is the same as Level II for wastewater treatment sludges.

Level II technology for lubricating and hydraulic oils is reclamation with landfill disposal of the unreclaimable residual. This technology may not find more widespread use due to the unfavorable economics of reclaiming small quantities of lubricating and hydraulic oils. Level III technology should include, in addition to Level II technology, disposal in a secured landfill of the unreclaimable residue due to possible oil and heavy metal toxicity from leachate if allowed to contaminate groundwater or surface water.

TABLE IV-2

TREATMENT AND DISPOSAL OF HALOGENATED SOLVENTS

| Factor | LEVEL I (Prevalent Technology) | LEVEL II (Best Technology Currently Employed) | LEVEL III (Technology for Adequate Health and Environmental Protection) |
|---|---|---|---|
| Physical & Chemical Properties of Residual Wastes | Liquid, chlorinated hydrocarbons slightly soluble in water with no flash point. | Same as Level I. | Same as Level I. |
| Description of Residual Waste | Liquid | Same as Level I. | Same as Level I. |
| Factors Affecting Degree of Hazard | Heavy metal content. Poisonous combustion products when improperly burned. | Same as Level I. | Same as Level I. |
| Treatment/Disposal Technology | On-and off-site reclamation. Drummed unreclaimable residue disposed of in landfill. | Same as Level I with disposal in secured landfill. | Same as Level II. |
| Estimated Number of Plants Using Technology | 900 | 100 | 100 |
| Adequacy of Technology | Inadequate. Runoff or leaching of heavy metal may occur, contaminating groundwater. | Adequate | Same as Level II. |
| Problems and Comments | Economically attractive alternative. | Few secured landfills available. | Same as Level II. |
| Non-land Environmental Impact | Possible leachate and runoff problems. Photochemical reactivity of volatilized solvents vented from landfill may contribute to air pollution. | Leachate and runoff problems minimized. | Same as Level II. |
| Compatability with Existing Facilities | Compatible when reclamation facilities are available. | Present limited availability of secured landfills. | Same as Level II. |
| Monitoring and Surveillance | None normally practiced. | Same as Level I. | Leachate monitoring. |
| Installation Time | None | 2-3 years for design, approval and construction of secured landfill. | Same as Level II. |
| Energy Requirements | For reclamation, hauling waste to landfill site, and operating landfill. | Same as Level I. | Same as Level I. |

TABLE IV-3

TREATMENT AND DISPOSAL OF NON-HALOGENATED SOLVENTS

| Factor | LEVEL I (Prevalent Technology) | LEVEL II (Best Technology Currently Employed) | LEVEL III (Technology for Adequate Health and Environmental Protection) |
|---|---|---|---|
| Physical & Chemical Properties of Residual Wastes | Liquid hydrocarbons. Soluble in water. | Same as Level I. | Incinerated ash consisting of metal oxides. Liquid still bottoms. |
| Description of Residual Waste | Liquid. | Same as Level I. | Dust and Liquids. |
| Factors Affecting Degree of Hazard | Toxic heavy metal content. Flash point generally less than 100°F except for still bottoms. | Same as Level I. | Still bottoms and ash may contain toxic heavy metals. |
| Treatment/Disposal Technology | Reclaimable: Off-site reclamation by distillation. Still bottoms to landfill. Unreclaimable: Drummed and landfilled. | Same as Level I with still bottoms and unreclaimable solvents to secured landfill. | Reclaimable: Same as Level II. Unreclaimable: Incineration with ash to secured landfill. |
| Estimated Number of Plants Using Technology | 900 | 200 | 0 |
| Adequacy of Technology | Inadequate. Runoff or leaching of heavy metals may occur, contaminating groundwater or surface water. Unreclaimed solvents flammable, resulting in acute hazard. | Inadequate. Unreclaimed solvents flammable, resulting in acute hazard. | Adequate. |
| Problems and Comments | Depends on available reclamation sites. Potential combustion in landfill. | Relatively few available secured landfill sites. Potential combustion in secured landfill. | Present limited availability of adequate incinerators and secured landfills. |
| Non-land Environmental Impact | Possible leachate and runoff problems. | Leachate and runoff problems minimized. | Same as Level II. |
| Compatability with Existing Facilities | Compatible when reclamation facilities are available. | Present limited availability of secured landfills. | Same as Level II plus limited availability of incinerators. |
| Monitoring and Surveillance | None normally practiced. | Same as Level I. | Leachate monitoring. |
| Installation Time | None | 2-3 years for design, approval and construction of secured landfills. | Same as Level II plus concurrent time for design, approval and construction of incinerators. |
| Energy Requirements | For reclamation, hauling waste to landfill site, and operating landfill. | Same as Level I. | For reclamation, hauling waste to incinerator and ash to landfill, covering ash with fill. Incinerated residue probably provides enough fuel for self-destruction. |

TABLE IV-8

TREATMENT AND DISPOSAL OF WASTEWATER TREATMENT SLUDGES

| Factor | LEVEL I (Prevalent Technology) | LEVEL II (Best Technology Currently Employed) | LEVEL III (Technology for Adequate Health and Environmental Protection) |
|---|---|---|---|
| Physical & Chemical Properties of Residual Wastes | Solid concentration of sludges range from 0.25%-97%, some of which consist of heavy metal salts. | Sludge containing at least 20% solids, some of which consist of heavy metal salts. | Same as Level II. |
| Description of Residual Waste | Sludge. | Same as Level I. | Same as Level I. |
| Factors Affecting Degree of Hazard | Heavy metal salts and fluorides may be toxic in landfill leachates. | Same as Level I. | Same as Level I. |
| Treatment/Disposal Technology | Off-site landfill. | On-site sludge dewatering with secured landfill disposal. | Same as Level II. |
| Estimated Number of Plants Using Technology | 700 | 200 | 200 |
| Adequacy of Technology | Inadequate. Runoff or leaching of heavy metal salts may occur, contaminating groundwater or surface water. | Adequate. | Adequate. |
| Problems and Comments | Most inexpensive available disposal technology. | Filter presses or centrifuges can be used for dewatering. | Same as Level II. Few secured landfills available. |
| Non-land Environmental Impact | Possible leachate and runoff problems | Minimal, assuming proper treatment/ disposal of wastewaters. | Same as Level II. |
| Compatability with Existing Facilities | Compatible. Need only collection receptacle, hauler, and off-site landfill. | Sludge dewatering process requires minimal land requirement. Present limited availability of secured landfills. | Same as Level II. |
| Monitoring and Surveillance | None normally practiced | None normally practiced. | Leachate monitoring. |
| Installation Time | None required. | 1-2 years for dewatering process design and installation. | 2-3 years for design, approval and construction of secured landfills. |
| Energy Requirements | For hauling sludge to landfill site and operating landfill. | Sludge dewatering, hauling sludge to landfill site and operating landfill. | Same as Level II. |

## TABLE IV-5

### TREATMENT AND DISPOSAL OF LUBRICATING AND HYDRAULIC OILS

| Factor | LEVEL I (Prevalent Technology) | LEVEL II (Best Technology Currently Employed) | LEVEL III (Technology for Adequate Health and Environmental Protection) |
|---|---|---|---|
| Physical & Chemical Properties of Residual Wastes | Dirty oil containing metal salts and sludge. | Oil-sludge mixture. | Same as Level II. |
| Description of Residual Waste | Viscous liquid. | Oily sludge. | Same as Level II. |
| Factors Affecting Degree of Hazard | Some oils and metal salts could be toxic. | Same as Level I. | Same as Level I. |
| Treatment/Disposal Technology | Off-site landfill. | On- and off-site reclamation with landfill disposal of sludge. | Same as Level II with disposal in a secured landfill. |
| Estimated Number of Plants Using Technology | 1600 | 800 | 0 |
| Adequacy of Technology | Inadequate. Runoff or leaching of oils or metal salts may occur, contaminating ground-water or surface water. | Same as Level I. | Adequate. |
| Problems and Comments | Most inexpensive, available disposal method. | Reclamation may not be economical when small oil quantities are used. | Same as Level II. Few secured landfills available. |
| Non-land Environmental Impact | Possible leachate and runoff problems. | Same as Level I. | Leachate and runoff problems minimized. |
| Compatability with Existing Facilities | Compatible. Need collection receptacle, hauler and off-site landfill. | Reclamation may be more economical off-site. | Present limited availability of secured landfills. |
| Monitoring and Surveillance | None normally practiced. | Same as Level I | Leachate monitoring. |
| Installation Time | None | Same as Level I. | 2-3 years for design, approval and construction of secured landfills. |
| Energy Requirements | For hauling oils to landfill site, and operating landfill. | For reclamation, hauling oils to landfill site, and operating landfill. | Same as Level II. |

## TABLE IV-6

### TREATMENT AND DISPOSAL OF PAINT WASTES

| Factor | LEVEL I (Prevalent Technology) | LEVEL II (Best Technology Currently Employed) | LEVEL III (Technology for Adequate Health and Environmental Protection) |
|---|---|---|---|
| Physical & Chemical Properties of Residual Wastes | Mixture of pigments, resin and solvents may contain heavy metals. | Incinerated ash consisting of pigments containing heavy metals. | Same as Level II. |
| Description of Residual Waste | Viscous liquid. | Dust | Same as Level II. |
| Factors Affecting Degree of Hazard | Toxic heavy metal salts. Solvents may be flammable. | Ash may contain toxic heavy metals. | Same as Level II. |
| Treatment/Disposal Technology | Off-site landfill mixed with plant trash. | Segregation from plant trash. Incineration with ash to off-site landfill. | Segregation from plant trash. Incineration with ash to secured landfill. |
| Estimated Number of Plants Using Technology | 1500 | 100 | 0 |
| Adequacy of Technology | Inadequate. Runoff or leaching of heavy metals may occur, contaminating groundwater or surface water. | Inadequate. Leaching of heavy metal pigment salts from ash may occur, contaminating groundwater or surface water. | Adequate. |
| Problems and Comments | Most inexpensive, available technology. | Present limited availability of adequate incinerators. | Same as Level II plus limited availability of secured landfills. |
| Non-land Environmental Impact | Possible leachate and runoff problems. | Air pollution control may be problem. | Same as Level II. |
| Compatability with Existing Facilities | Compatible. Need collection receptable, hauler and off-site landfill operation. | Compatible. Ideally, incinerator should be located adjacent to landfill site. Separate, fire- and leak-proof containers for on-site storage required. | Present limited availability of secured landfills. |
| Monitoring and Surveillance | None normally practiced. | None normally practiced. | Leachate and incinerator stack gas monitoring. |
| Installation Time | None required. | Incinerator could take 2-3 years from design to start up. | Same as Level II. |
| Energy Requirements | For hauling paint wastes to landfill site and operating landfill. | For hauling waste to incinerator supplemental fuel for incinerator transferring ash to landfill; operating landfill. | Same as Level II. |

Level II technology for paint wastes is incineration with landfill disposal of the ash. Only a few plants practice this technology because of the limited availability of incinerators and the small quantities of paint waste generated. Due to the flammability of some of the paint wastes, Level III technology should be the same as Level II with disposal of the ash in a secured landfill to prevent leachate contamination of the groundwater or surface water.

# SECTION V

# COST ANALYSIS

## INTRODUCTION

The potentially hazardous waste treatment and disposal costs for Level I technology are discussed first for each of the five basic waste streams. This is followed by an evaluation of Level II and Level II costs. A summary table showing treatment and disposal costs for each major waste stream at each technology level is also provided. Estimated annual costs to the industry as a whole are given and compared with the profitability of the industry.

An assessment of potentially hazardous waste treatment and disposal costs for an average plant is provided for each of the three technology levels. These costs are based on the implementation of off-site treatment and disposal practices due to their prevalence within the industry.

Due to the relative scarcity of usable cost data from the plant surveyed, it was not generally possible to assess the factors which most strongly affect the variability of potentially hazardous waste treatment and disposal costs for this industry.

Cost data were difficult to obtain during the surveys due to a lack of:

1. Reliable cost information
2. Reliable information on the quantities of waste generated
3. Reluctance of the plants to release cost information.

Supplemental cost data were taken from the industry and government literature and information supplied by waste disposal contractors. These are referenced in the discussion.

Level III technology is not generally being implemented by the electronic component manufacturing industry. Cost estimates for this technology were derived from literature sources referenced in this section.

A key feature of this cost analyses is that the costs given for each technology level are based on off-site waste disposal. The reasons for this are:

1. Eighty-seven percent of wastes quantified in surveyed plants was disposed of off-site.

2. Most existing plants are located in predominantly urban areas where space availability for treatment and disposal facilities on-site would be a major problem.

3. For all but the very largest establishments, most types of potentially hazardous wastes are generated in small enough quantities that environmentally adequate on-site treatment and/or disposal would be economically unattractive compared with off-site alternatives -- even those comprising Level III technology.

## TREATMENT AND DISPOSAL COSTS

### Level I Technology

Level I technology is defined by EPA as the prevalent technology currently employed -- i.e., the broad average present treatment and disposal practice. The costs of handling, treating, and disposing of each waste stream of the subject industries are discussed below.

Halogenated Solvents - Waste halogenated solvents are commonly found in electronic component manufacturers' plants. The most prevalent method for treating and disposing of these wastes consists of reclaiming off-site by private contractors. Residue from reclaiming operations is disposed of in a landfill operation. Interestingly enough, the electronic component manufacturers are often paid for this waste solvent by the solvent reclaimers. Plant survey data show that the range of credit given to the plants for the solvent is \$40-\$55/kkg (\$36-\$50/ton) with an average value of \$51/kkg (\$46/ton).

There seems to be two basic reasons why solvent reclaimers are willing to pay for these spent solvents. First, the spent solvents often require little, if any, reprocessing. Sometimes, they can be sold directly from the drums in which they are received. Second, electronic component manufacturers sometimes negotiate contracts for a given firm to handle several "waste" or reject streams from a plant some of which will contain precious metals. Contractors may take a small loss on spent solvent in order to secure a plant's scrap metal.

Roughly 40 percent of waste solvents are disposed off-site in landfill operations. One plant reported a cost of \$121/kkg (\$110/ton) for the disposal of 5.0 kkg/yr (5.5 tons/yr) of spent chlorinated solvent, but little additional data for landfilling this type of material was obtained from the site visits. Based on the surveys of plants in the machinery industry, it is expected that the cost of landfilling halogenated solvents is roughly \$55/kkg (\$50/ton).

Nonhalogenated Solvents - Level I technology for reclaimable nonhalogenated solvents is off-site reclamation with residue disposal in a landfill. Nonreclaimable wastes are disposed of in a landfill operation. As with the halogenated solvents, electronic component manufacturers are sometimes paid for their waste solvent by solvent reclaimers. A much smaller proportion of the nonhalogenated solvent waste stream is economically reclaimable because of greater contamination of the wastes and lower cost for new solvent than for halogenated solvents.

A wide range of prices were charged for reclaimable spent solvents by the manufacturers, according to the plant site surveys. This range was \$15-\$130/ kkg (\$14-\$118/ton) with an average of \$40/kkg (\$36/ton). Acetone was the waste solvent involved at both the low end and the high end of the cost range. Methanol and isopropyl alcohol were also commonly found in the plants surveyed.

Separate cost data for nonreclaimable solvents are not usually maintained by the plants according to the surveys. It is estimated on the basis of visits to special machinery manufacturing plants [33] that disposal of nonreclaimable, nonhalogenated solvents in landfill operations is approximately \$55/kkg (\$50/ton) for Level I.

Wastewater Treatment Sludge - Wastewater treatment sludges generated by electronic component manufacturers are usually disposed of by a private contractor at some type of landfill operation. Based primarily on survey data from this industry as well as from the special machinery manufacturing industry, it appears that the cost of landfilling wastewater treatment sludges is approximately \$22/kkg (\$20/ton).

Lubricating and Hydraulic Oils - Waste lubricating and hydraulic oils are generally disposed of in an off-site landfill by a private contractor. This constitutes Level I technology for waste oils in this industry.

Disposal cost data for this waste from the site visits were sparse, probably since most of the plants tend to combine waste oils with other process wastes and garbage, rather than handling the oils separately. However, data obtained from plant surveys in the special machinery manufacturing industry show that the average cost for land disposal of waste oil is \$22/kkg (\$20/ton).

Paint Wastes - Level I technology for paint wastes consists of hauling and disposal by a private contractor to an off-site landfill operation. The waste stream consists of paint sludge, residue, and some dry filters and rags. Because of the relatively small quantities of paint wastes generated at most electronics manufacturing plants, separate disposal cost data are not usually determined. However, data obtained from visits to similar sites in the special machinery industry show that paint wastes disposal on landfill operations costs about \$10/kkg (\$9/ton).

## Level II Technology

Level II potentially hazardous waste treatment and disposal technology is defined as the best technology currently employed as found through site surveys or in the literature. Identified technology at this level must represent the soundest process from an environmental and health standpoint currently in use in at least one manaufacturing location.

Halogenated Solvents - Level II technology for reclaimable solvents is off-site reclamation by a private contractor with still bottoms (if any) disposed of in a secured landfill. The plant using this technology could not supply adequate cost information, so it has been calculated, based on other data collected in this study, that the average amount received by the manufacturer is approximately \$48/kkg (\$44/ton). It is assumed that the cost of secured landfilling will be passed on to manufacturer by the reclaiming contractor. Level II technology for nonreclaimed solvents is off-site disposal in a landfill operation. As noted previously, the cost of this practice is approximately \$55/kkg (\$50/ton).

Nonhalogenated Solvents - Level II technology for reclaimable solvents consists of off-site reclamation with disposal of any still bottoms generated in a secured landfill. As noted in the previous section, it is estimated that roughly 200 manufacturing establishments make use of this technology.

One SIC 367 plant implementing this technology reported receiving \$50/kkg (\$45/ton) for spent solvent. It has been calculated, based on Level I technology costs and the incremental cost for disposing of still bottoms in a secured landfill instead of a sanitary landfill, that the average amount of money received by plants for their waste solvent is \$37/kkg (\$34/ton). Level II technology for nonreclaimable waste solvent consists of off-site disposal in a secured landfill operation. Based primarily on a recent study of the hazardous waste management service industry [37], the cost of this practice is roughly \$62/kkg \$57/ton). The range of values used to determine this cost was \$15-\$63/kkg (\$14-\$57/ton). The higher value was selected to be consistent with the industry-reported data for Level I of \$55/kkg \$50/ton) and to provide an allowance for disposal in a "secured" landfill versus a sanitary landfill.

Wastewater Treatment Sludges - Level II treatment and disposal technology for wastewater treatment sludges consists of dewatering followed by disposal in a secured landfill operation. Dewatering plus disposal in secured landfills will add up to \$11/kkg (\$10/ton) to the Level I cost, resulting in a total cost of approximately \$33/kkg (\$30/ton).

Lubricating and Hydraulic Oils - The reclamation of waste oils off-site by a private contractor has been determined to be Level II technology. Residues and sludges from the reclaiming operations were disposed of in a landfill operation. No directly applicable cost data from the electronics component manufacturing industry were available, but similar operation in the special machinery manufacturing industry [33] showed that the average cost for this technique is roughly \$19/kkg (\$17/ton), although costs tend to vary over a wide range. The main reason for this appears to be the quality of the waste oil prior to rerefining -- i.e., the amount of "dirt" it contains. For example, the prices quoted for small lots of waste oil by a midwestern rerefining contractor are as follows:

| "Dirt" Concentration in Oil | Price Range | |
|---|---|---|
| | ¢/liter | ¢/gal. |
| 15% | 0-1 | 1-5 |
| 10-15% | 0 | 0 |
| 10% | [0-7] | [1-7] |

Dirt concentrations are determined mainly by visual means. The contractor will pay up to 2¢/liter (7¢/gallon) for relatively clean oil which can be more easily rerefined. On the other hand, some of the dirtier oils obtained may be used for road oiling instead of rerefining. Another contractor, however, charges $22/kkg ($20/ton) for waste oils which are sold in turn to rerefining operations.

The estimated cost for Level II treatment and disposal of waste oils, $19/kkg ($17/ton), reflects a small savings over Level I costs due to credits accruing from reclamation.

Paint Wastes - Level II technology for paint waste consists of incineration with ash disposed of in an off-site landfill. Based primarily on data compiled for a similar waste stream of the special machinery manufacturing industry, it appears that this technology costs approximately $51/kkg ($46/ton) which includes approximately $20/kkg $19/ton) for waste hauling, ash disposal, and a fee. One plant reported a cost of on-site incineration alone to be $36/kkg ($33/ton).

## Level III Technology

Level III technology is defined as the treatment and disposal technology necessary to provide adequate health and environmental protection. Level III technology may be more or less sophisticated or may be identical to Level I or Level II technology. At this level, identified technology may include pilot or bench scale processes providing the exact stage of development is identified.

Halogenated Solvents - Level III technology for this waste stream is the same as for Level II -- off-site reclamation with still bottoms disposal as required in a secured landfill operation for reclaimable solvents, and direct disposal in a secured landfill for nonreclaimable solvents. As noted previously, the average amount received by electronic component manufacturers for reclaimed solvents is about $48/kkg ($44/ton). The hauling and disposal of nonreclaimable solvents cost about $55/kkg ($50/ton).

Nonhalogenated Solvents - Level III technology for reclaimable solvent is the same as Level II, consisting of off-site reclamation with disposal of still bottoms in a secured landfill operation. This technology yields an average of $37/kkg ($34/ton) to the electronic component manufacturing plants.

Level III technology for the treatment and disposal of nonreclaimable nonhalogenated solvents is incineration with ash disposal in secured landfills. Based on data contained in the recent EPA-sponsored study of the hazardous waste management service industry [37], it has been calculated that the cost of this practice is approximately $62/kkg ($57/ton). This is based on an incineration cost of $41/kkg ($37/ton), a secured landfilling cost of $21/kkg ($19/ton), and an ash generation of 0.1 kkg/kkg of waste.

Wastewater Treatment Sludges - Level III technology for the treatment and disposal of wastewater treatment sludges is the same as Level II -- on-site sludge dewatering followed by secured landfill disposal. As noted previously, this costs about $33/kkg ($30/ton).

Lubricating and Hydraulic Oils - Waste oils generated by electronic component manufacturers should be reclaimed, with residual sludge being disposed of in a secured landfill operation. It has been calculated, based on data from the machinery industry surveys [33] and the report on the hazardous waste management service industry [37], that the cost of this practice is approximately $27/kkg ($24/ton).

Paint Wastes - Level III technology consists of segregation from plant trash, and incineration followed by ash disposal in secured landfills. It has been calculated, based on data contained in another EPA report [33], that this practice costs $54/kkg ($39/ton).

Table V-1 summarizes the estimated treatment and disposal costs for each potentially hazardous waste stream discussed above. Based on this information, plus the estimated generation rate of these wastes in 1975, the total treatment and disposal costs to the industry are listed in Table V-2. The total cost for treating and disposing of all potentially hazardous wastes of the industry using Level I technology is $1,258,000/year. Level II technology applied to 1975 waste generation rates would increase costs by 34 percent to $1,683,300/year. Similarly, Level III technology would increase costs by 35 percent over Level I technology to $1,696,000. The cost increase between Level I and Level II technology results primarily from dewatering and secured landfilling of wastewater treatment sludges and from secured landfilling of unreclaimable nonhalogenated solvents. Additional cost increases between Level II and III are due to increased reclamation of lubricating and hydraulic oils with secured landfilling of residual oil sludges and to segregation and incineration of paint wastes followed by ash disposal in a secured landfill. Since the oil and paint waste stream quantities are small compared to the other major waste streams, the overall cost increase to the industry for Level III above Level II is less than one percent.

## IMPACT OF POTENTIALLY HAZARDOUS WASTE MANAGEMENT COSTS TO THE INDUSTRY

The costs of treatment and disposal for potentially hazardous wastes for either of the three technology levels described here are judged to have an insignificant impact on the profitability of the

## TABLE V-1

## ESTIMATED POTENTIALLY HAZARDOUS WASTE TREATMENT AND DISPOSAL COSTS

| | $/kkg of Waste on Wet Weight Basis ($/ton) | | |
|---|---|---|---|
| PROCESS WASTE | LEVEL I | LEVEL II | LEVEL III |
| Halogenated Solvents | | | |
| Reclamable (credit) | [51(46)][1] | [48(44)][1] | [47(44)][1] |
| Non-Reclamable | 55(50)[1] | 55(50)[1] | 55(50)[1] |
| Non Halogenated Solvents | | | |
| Reclamable (credit) | [40(36)][1] | [37(34)][1] | [37(34)][1] |
| Non-Reclamable | 55(50)[1] | 62(57)[2] | 62(57)[2] |
| Waste Treatment Sludge | 22(20)[3] | 33(30)[4] | 33(30)[4] |
| Lubricating and Hydraulic Oils | 22(20)[3] | 19(17)[3] | 27(24)[3] |
| Paint Wastes | 10(9)[3] | 51(46)[3] | 54(49)[3] |

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[1] Plant Data or Industry Data.

[2] Source: Reference [37].

[3] Source: Reference [33].

[4] Source: Reference [43].

## TABLE V-2

## TOTAL NATIONAL COSTS TO THE ELECTRONIC COMPONENTS MANUFACTURING INDUSTRY FOR POTENTIALLY HAZARDOUS WASTE TREATMENT AND DISPOSAL

| | COST $THOUSAND/YEAR[3,4] | | |
|---|---|---|---|
| PROCESS WASTE | LEVEL I | LEVEL II | LEVEL III |
| Halogenated Solvents[1] | -92.7 | -73.3 | -73.3 |
| Nonhalogenated Solvents[2] | 700.7 | 802.32 | 802.32 |
| Wastewater Treatment Sludge | 609.84 | 914.8 | 914.8 |
| Lubricating and Hydraulic Oils | 33.9 | 29.3 | 41.6 |
| Paint Wastes | 2.0 | 10.2 | 10.8 |
| TOTAL | 1,258 | 1,683.3 | 1,696 |

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[1] Assume from Industry data 60% recoverable 40% nonrecoverable.

[2] Assume from Industry data 10% recoverable 90% nonrecoverable.

[3] Incorporating costs listed in Table V-1 and 1975 waste quantities in Table III-1.

[4] Wet weights of waste stream used in quantification.

electronic components manufacturing industry as a whole. Based upon before tax profitability for SIC 36 - Electrical and Electronic Equipment for three quarters in 1975 and the first quarter of 1976, the electronic components manufacturing industry is estimated to have had a 6.15 percent average profitability (profit per sales dollar) before taxes [44] for the period of the survey. At an estimated value of industry shipments of $10,395,000,000 for 1975 [10] the industry profit for the year is calculated to have been approximately $639,000,000. These statistics and the percent of profit represented by technology Levels I, II and III costs are presented in Table V-3.

Thus, the incremental cost of implementing Level II or Level III technology will not significantly affect the financial position of the electronic component manufacturing industry as a whole.

## TREATMENT AND DISPOSAL COSTS AT AN AVERAGE PLANT

Based on Census data [10], the average manufacturing plant in SIC 367 employs 109 production workers and generates sales of approximately $4 million per year. Such a plant also generates about 22.2 kkg/yr (24.4 tons/yr) of potentially hazardous wastes as shown in Table V-4. The costs of the treatment and disposal of these wastes are $501/year for Level I, $673/year for Level II, and $678/year for Level III technology.

Summary information on plant characteristics, potentially hazardous waste streams, treatment and disposal costs and treatment and disposal technologies for an "average plant" in the industry is presented in Table V-5.

## TABLE V-3

## SIC 367 PROFITABILITY, 1975 TOTAL PROFITS, AND COMPARISONS BETWEEN TOTAL PROFITS AND POTENTIALLY HAZARDOUS WASTE TREATMENT AND DISPOSAL COSTS

- Average profit before taxes = 6.15% per sales dollar[1]
- Value of Industry Shipments - SIC 367 = \$10,395 million[2]
- Calculated 1975 profit = \$639 million

| | Level I Technology | Level II Technology | Level III Technology |
|---|---|---|---|
| Total Estimated Cost[3] to SIC 367 for Treatment and Disposal of Potentially Hazardous Wastes in \$thousand/yr. | 1,258 | 1683.3 | 1696. |
| Percent of 1975 profit before taxes | 0.2 | 0.26 | 0.27 |

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[1] Profit assumed to be equal to SIC 36 as a whole.(44) No data is available for SIC 367 individually.

[2] Source: Reference (10).

[3] From Table V-2.

## TABLE V-4

## TREATMENT AND DISPOSAL COSTS FOR POTENTIALLY HAZARDOUS WASTES AT AN AVERAGE ELECTRONIC COMPONENTS MANUFACTURING PLANT BY WASTE STREAM AND TREATMENT AND DISPOSAL TECHNOLOGY LEVEL[1]

| Potentially Hazardous Waste Stream | Waste Generation Rate per Plant (kkg/year) | | Plant Cost in $/year | | |
|---|---|---|---|---|---|
| | | | Level I | Level II | Level III |
| Halogenated Solvents[2] | 4.3 | | | | |
| reclaimable | | 2.58 | [132] | [124] | [124] |
| non-reclaimable | | 1.72 | 94.6 | 94.6 | 94.6 |
| Non-Halogenated Solvents[3] | 6.16 | | | | |
| reclaimable | | .62 | [24.6] | [22.8] | [22.8] |
| non-reclaimable | | 5.54 | 305 | 344 | 344 |
| Wastewater Treatment Sludges | 11.1 | | 244 | 366 | 366 |
| Lubricating and Hydraulic Oils | 0.6 | | 13.2 | 11.4 | 16.2 |
| Paint Wastes | 0.08 | | .8 | 4.1 | 4.3 |
| Totals | 22.24 | | 501.0 | 673.3 | 678.3 |

---

[1] Based on 2,500 plants in 1975 [10], 1975 waste stream generation rates from Table III-1, and unit costs from Table V-1.

[2] Assume 60% reclaimable; 40% non-reclaimable.

[3] Assume 10% reclaimable; 90% non-reclaimable.

### TABLE V-5

### AVERAGE PLANT COSTS FOR TREATMENT DISPOSAL, 1975
### SIC 367 - ELECTRONIC COMPONENTS MANUFACTURING INDUSTRY

Plant Characteristics:

Annual production - $4.2 million value of shipments
Location - urban or suburban area in North Atlantic, Great Lakes or West Coast states.
Manufacturing Processes - No typical processes. Industry is typified by a high degree of product and manufacturing process diversity.

| Potentially Hazardous Waste Streams: | Composition | Physical Form | Amount for Treatment-Disposal per Plant (kkg/yr) Wet Weight |
|---|---|---|---|
| Halogenated Solvents | Perchloroethylene<br>Trichloroethane<br>1,1,1 Trichloroethylene<br>Freons<br>Methylene Chloride<br>Still bottoms from reclamation of above solvents | Liquid to semi-solid for still bottoms | 4.3 |
| | (60% reclaimable; 40% nonreclaimable) | | |
| Nonhalogenated Solvents | Mixed solvents (halogenated and nonhalogenated)<br>Methanol<br>Acetone<br>Alcohols<br>Proprietary photoresists<br>Xylene | Liquid to semi-solid for still bottoms and slurries | 6.16 |
| | (10% reclaimable; 90% nonreclaimable) | | |
| Wastewater Treatment Sludges | Particulate metals and oxides<br>Chemically precipitated anions and cations<br>Oils<br>Solvents | Liquid to semi-solid. 2-98% solids. | 11.1 |
| Lubrications and Hydraulic Oils | Water-soluble oils<br>Petroleum derived oils | Liquid | 0.6 |
| Paint Wastes | Spray booth filters<br>Clean up rags<br>Solvent/paint mixtures | Solids and liquids | .08 |

| Treatment/Disposal Cost/Technology Level: | Level I | Level II | Level III |
|---|---|---|---|
| Contractor Services | $501.00 | $673.30 | $678.30 |

[See Table V-4 for cost/waste stream. On-site treatment/disposal is not typical for this industry.]

Continued

Table V-5 - Cont'd.

Treatment/Disposal Technology:

| Level | Halogenated Solvents | Nonhalogenated Solvents | Wastewater Treatment Sludges | Lubricating and Hydraulic Oils | Paint Wastes |
|---|---|---|---|---|---|
| I | On- and off-site reclamation. Drummed unreclaimable residue disposed of in landfill. | Reclaimable: Off-site reclamation by distillation. Still bottoms to landfill. Unreclaimable: Drummed and landfilled. | Off-site landfill. | Off-site landfill. | Off-site landfill mixed with plant trash. |
| II | Same as Level I with disposal in secured landfill. | Same as Level I with still bottoms and unreclaimable solvents to secured landfill. | On-site sludge dewatering with secured landfill disposal. | On- and off-site reclamation with landfill | Segregation from plant trash. Incineration with ash to off-site landfill. |
| III | Same as Level II. | Reclaimable: Same as Level II. Unreclaimable: Incineration with ash to secured landfill | Same as Level II. | Same as Level II with disposal a secured landfill. | Segregation from plant trash. Incineration with ash to secured landfill. |

## SECTION VI

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# SECTION VII

## GLOSSARY

Acute toxicity - any poisonous effect produced within a short period of time, usually up to 24-96 hours, resulting in severe biological harm and often death.

Baking - any process involving heating of components to alter the physical or chemical nature of one or more component parts.

Bioconcentration -the accumulation of substances in living organisms resulting from ingestion and/or differential absorption of the substances in living tissue vs. environmental media.

Carcinogen - a substance or agent producing or inciting cancer.

Casting plastics - encapsulation or sealing of components by means of two-part epoxy resins poured, spread, or painted onto the component.

Coverage ratio - proportion of primary products shipped by the establishments in the industry to total shipments of such products by all manufacturing establishments.

Doping - addition of impurities to silicon surfaces by baking the exposed silicon in the presence of a non-reactive gas containing the impurity; also "epitaxial deposition."

Drag-out - the amount of solution carried out of an electroplating or other surface finishing bath by the details immersed and the racks holding the article.

Dry booth painting - a material coating process involving spray painting of various types of paint on components in partially enclosed ventilation chambers. Waste paint particles are removed from the air stream by dry filtration.

Electroplating - electrodisposition of a metal or alloy from a suitable electrolyte solution: the article to be plated is connected as the cathode in the electrolyte solution; direct current is introduced through the anode which consists of the metal to be deposited.

Etching - removal of oxides from metals with the use of acids.

Electroless plating - a metal deposition process employing a chemical reducing agent to reduce a metal salt so that it will deposit on a catalytic surface.

Flash point - the temperature at which the vapor of a material will ignite when exposed to a small flame under controlled test conditions.

Furnace soldering - an assembly operation in which preformed solder is applied to metal component parts by baking.

Glass forming - any process in which glass materials are molded or joined.

Glass fritting - the joining of glass to glass with the use of lead-containing glass.

Gold termination - dipping component parts in molten gold to provide a thin gold film.

Hazardous constituent - a constituent of a process waste or waste stream which meets the definition of "hazardous" detailed in this report.

Incineration - the controlled process by which solid, liquid or gaseous combustible wastes are burned and changed into gases; the residue produced contains little or no combustible materials.

Incinerator - an engineered apparatus used to burn waste substances and in which all the combustion factors -- temperatures, retention time, turbulence and combustion air -- can be controlled.

Leachate - liquid that has percolated through solid waste or other mediums and has extracted dissolved or suspended materials from it.

Leaching - the process by which soluble materials in the soil, such as nutrients, pesticide chemicals or contaminants, are washed into a lower layer of soil or are dissolved and carried away by water.

Mechanical etching - the removal of thin films on coated component parts with the use of a sharp stylus.

Mechanical lead attachment - attachment of wire leads to components using clip devices to provide an electrically sound connection.

Milling - grinding of materials to a fine powder so that it will mix uniformly in liquid vehicles.

Mutagen - a substance that tends to increase the frequency of mutations.

N.E.C. - also written as n.e.c. - Not elsewhere classified.

Non-plastic molding - the forming, by extrusion or filter pressing, of non-plastic, composition materials.

Organic coating - a material coating process in which the component is dipped into a varnish or lacquer and solvent bath.

Phosphor deposition - the coating of television picture tube screens with a water-based vehicle containing organic binders and various metal salts (phosphors).

pH - a measure of the acidity or alkalinity of a material, liquid or solids; pH is represented on a scale of 0 to 14 with 7 representing a neutral state, 0 representing the most acid and 14, the most alkaline.

Photoresist application - the coating of silicon wafers or television picture tube screens with various organic photoresists.

Plastics molding - the process of forming shapes of plastic materials using dies.

Primary product - the product of a manufacturing plant (or the products SIC designation) which makes the greatest contribution to the plants value of shipments.

Process waste - any material discarded as a function of a manufacturing operation, whether land-disposed or not.

Primary product specialization ratio - proportion of product shipments (both primary and secondary) of the establishments classified in the industry represented by the primary products of those establishments.

Product area - the class of manufacturing plants which produce a given product as defined by four-digit SIC's for SIC's 3671 through 3678 and by five- or seven-digit SIC's for SIC 3679. This designation was established to maximize the amount of material and process flow similarity for products grouped by SIC.

Sawing and cutoff - any operation which alters the size or shape of metal or non-metal material by mechanical means.

Scribing - separation of silicon-based semiconductor elements by scratching the silicon surface and breaking off the element from the wafer.

Still bottoms - the heavy ends remaining in distillation equipment after solvent reclamation.

Teratogen - a substance or agent which tends to cause developmental malformations or monstrosities.

Thermoforming plastics - plastics molding using the application of heat. Includes thermoplastic molding and thermosetting.

Thermoplastic polymers - a plastic which reverts to a fluid state upon the application of heat.

Thermosetting polymers - a plastic which does not revert to a fluid state upon the application of heat.

Vacuum metalizing - condensation of thin metal coatings on the cool surface of a metal piece in a vacuum.

Value of industry shipments - total value of shipments from plants classified within an SIC according to their primary product.  Includes value primary and secondary products plus services performed.

Value of product shipments - the value of shipments of any product within an SIC regardless of the plant's SIC where produced.

Waste category - classes of process wastes grouped according to origin (as wastewater treatment sludges) or chemical characteristics of the most common or most hazardous constituent.

Waste stream - any waste category that is typically land disposed in significant amounts by the electronic components manufacturing industry or their contractors.

Welding - joining two or more pieces of material by applying heat, pressure, or both, with or without filler material to produce a localized union through fusion or recrystallization across the interface.

# APPENDIX A

## PRODUCTS OF THE ELECTRONIC COMPONENTS MANUFACTURING INDUSTRY
## SIC 367

| SIC Code | Industries and Products |
|---|---|
| 3671- — | ELECTRON TUBES, RECEIVING TYPE |
| 36710 11 | Standard, GT, and GT/G |
| 36710 12 | Miniature |
| 36710 13 | Subminiature |
| 36710 15 | Other |
| 3672- — | CATHODE RAY PICTURE TUBES, INCLUDING REBUILT |
| | Television picture tubes, including rebuilt: |
| 36720 13 | Black and white |
| 36720 15 | Color |
| | TRANSMITTAL, INDUSTRIAL, AND SPECIAL PURPOSE ELECTRON TUBES (EXCEPT X-RAY): |
| | Power and special purpose tubes: |
| 36730 11 | High vacuum tubes |
| 36730 22 | Gas and vapor tubes |
| 36730 27 | Klystrons |
| 36730 51 | Magnetrons |
| 36730 91 | Forward wave tubes |
| 36730 92 | Backward wave tubes |
| 36730 93 | Light sensing tubes |
| 36730 94 | Light emitting and special purpose display tubes |
| 36730 95 | Storage tubes |
| 36730 96 | Miscellaneous special purpose tubes |
| 3674- — | SEMICONDUCTORS |
| 36741 — | Integrated Microcircuits, (Semiconductor Networks): |
| 36741 13 | Monolithic, digital |
| 36741 23 | Monolithic, analog |
| 36741 15 | Chip, all types |
| 36741 25 | Chip, all types |
| 36742 | Transistors: |
| 36742 61 | Silicon |
| 36742 65 | Germanium |
| 36742 67 | Other (gallium arsenide, silicon carbide, etc.) |

| | |
|---|---|
| 36743 — | Diodes and Rectifiers: |
| 36743 23 | Silicon |
| 36743 43 | Germanium |
| 36743 13 | Selenium and copper oxide |
| 36743 91 | Other |
| 36749 -- | Other Semiconductor Devices: |
| 36749 92 | Solar cells |
| 36749 93 | Other |
| 36749 94 | Zener diodes, (voltage regulator and voltage reference diodes) |
| 36749 95 | Other semiconductor devices |
| 36749 96 | Semiconductor parts (chips, headers, cams, etc.) |
| 36740 00 | Semiconductor devices, N.S.K., for establishments with 10 employees or more |
| 36740 02 | Semiconductor devices, N.S.K, for establishments with less than 10 employees |
| 36750 00 | CAPACITORS FOR ELECTRONIC APPLICATIONS |
| 36750 12 | Paper, metalized paper, film, and dual dielectric |
| 36750 21 | Aluminum electrolytic (a.c. and d.c.) |
| 36750 31 | Tantalum electrolytic |
| 36750 41 | Ceramic dielectric |
| 36750 51 | Mica dielectric |
| 36750 61 | Capacitors for automotive ignition systmes |
| 36750 62 | Other |
| | RESISTORS FOR ELECTRONIC APPLICATIONS |
| 36760 11 | Composition, fixed |
| 36760 51 | Deposited carbon and metal film, fixed |
| 36760 31 | Wire-wound, fixed |
| 36760 15 | Variable nonwire-wound, precision and nonprecision |
| 36760 36 | Variable wire-wound, precision and nonprecision |
| 36760 55 | Other (thermistor, thermistor-bolometers, varister, etc.) |
| | Coils, Transformers, Reactors, and Chokes for Electronic Applications: |
| 36770 32 | Audio transformers |
| 36770 33 | Low frequency chokes and filters |
| 36770 41 | Plate and filament transformers, including autotransformers, except toroidal |
| | Pulse transformers: |
| 36770 62 | Computer types |
| 36770 63 | Other types |
| 36770 12 | RF chokes |
| 36770 13 | RF coils and IF transformers |

| | |
|---|---|
| 36770 71 | Television transformers and reactors (horizontal output, vertical deflection, focus coils, deflection yokes, etc.) |
| 36770 91 | Toroidal windings (transformers and reactors), except complete magnetic amplifiers |
| 36770 92 | Other (balum coils, permeability tuning devices, etc.) |
| | ELECTRONIC CONNECTORS: |
| 36780 81 | RF |
| 36780 82 | Cylindrical |
| 36780 83 | Rack and panel |
| 36780 84 | Printed circuit |
| 36780 85 | Fusion sealed |
| 36780 86 | Other |
| | Electronic Components, N.E.C., Except Phonograph Needles and Cutting Styli |
| | Magnetic Recording Media: |
| 36790 01 | Audio range tape |
| 36790 02 | Computer tape |
| 36790 04 | Video tape |
| 36790 13 | Electron tube parts, except glass blanks |
| 36790 31 | Phonograph cartridges and pickups |
| | Complex components (two or more components packaged and shipped as a single unit), except filters and other items listed elsewhere: |
| 36790 21 | Passive component packages, or "modules" assembled from conventional components (RC networks, tone control packages, interstage coupling packages) |
| 36790 22 | Active component packages or "modules" assembled from conventional components |
| 36970 23 | Active or passive component packages of "modules" (assembled from components fabricated during the assembly process or from specially designed, discrete, miniature components designed only for use in modules) |
| 36790 32 | Switches, mechanical types for electronic circuitry (coaxial, tap, rotary wafer, slide selector, and similar types) |
| | Cutting Components,, n.e.c., Except Phonograph Needles and |
| | Static power supply converters for electronic applications, sold separately: |
| 36790 43 | Regulated |
| 36790 44 | Unregulated |
| 36790 45 | Variable frequency |
| 36790 46 | Other (a.c., d.c., converters and inverters, klystrom, vibrator etc.) |
| | Relays for electronic applications: |
| 36790 33 | Clapper, rotary, plunger, or solenoid |
| 36790 34 | Other |

| | |
|---|---|
| 36790 35 | Home antennas |
| 36790 37 | Auto antennas |
| 36790 38 | Antennas accessories, sold separately |
| 36790 52 | Printed circuit boards, printed cables, and forms already etched, placed, etc., ready for component insertion |
| | Transducers, electrical/electronic input or output, n.e.c.: |
| | Accoustical: |
| 36790 11 | Sonar |
| 36790 12 | Ultrasonic, vibration, etc. |
| | Mechanical: |
| 36790 14 | Accelerometers |
| 36790 15 | Pressure |
| 36790 16 | Strain gages and other mechanical |
| 36790 18 | Thermal; Pyrometers, thermo-couples, etc., excluding bimetallic, mercury, and other mechanical output types |
| 36790 19 | Other optical (including any not covered under crystal, etc.), chemical, magnetic, nuclear, etc. |
| 36790 28 | Delay lines |
| 36790 29 | Earphones and headsets, except telephone |
| | Microwave components and devices, except antennas, tubes, and semiconductors: |
| | Ferrite (including yttrium garnets) microwave components: |
| 36790 61 | Circulators, all types, permanent magnet |
| 36790 62 | Circulators, electromagnetic, used as switches, modulators, etc. |
| 36790 64 | Phase shifters |
| 36790 65 | Other ferrite microwave components |
| 36790 63 | Isolators |
| | Microwave devices, other than ferrite and solid state: |
| 36790 66 | Attenuators, dummy loads, high and low power terminations, etc. |
| 36790 67 | Cavities |
| 36790 68 | Couplers: (directional couplers, hybrid junctions, etc.) |
| 36790 69 | Duplexers and diplixers, except electric tubes and ferrite devices |
| 36790 71 | Reactive microwave components, n.e.c. |
| 36790 73 | Rotary joints and sector scan joints |
| 36790 74 | Switches, coaxial and waveguide |
| 36790 75 | Rigid waveguides and fittings |
| 36790 77 | Flexible waveguides and fittings |
| 36790 78 | Other microwave components, except ferrite devices |
| | Mircrowave subassemblies: |
| 36790 56 | Parametric amplifiers |
| 36790 57 | Other solid state assemblies (frequency multipliers, harmonic generators, etc.) |

| | |
|---|---|
| | Crystals, filters, and related devices: |
| | Filters, except microwave: |
| 36790 92 | LC, RC, etc. |
| 36790 91 | Infrared, ultra-violet, etc., excluding optical lenses (germanium silicon, fused quartz, rock salt, and other) |
| 36790 93 | Mechanical |
| 36790 94 | Quartz and other piezoelectric filters |
| 36790 95 | Quartz crystals |
| 36790 96 | Other crystals (ADP, Rochelle salt, ruby, garnet, etc.) |
| 36790 39 | Electronic parts, n.e.c., and specialized electronic hardware. |

# APPENDIX B

# WASTE GENERATION VOLUMES FOR THE ELECTRONIC COMPONENTS MANUFACTURING INDUSTRY

## ELECTRONIC COMPONENTS MANUFACTURING
## SIC 367
## PROCESS WASTE GENERATION — HALOGENATED SOLVENTS
## 1975 State and EPA Region Totals
## (kkg/year)

| State | EPA Region | Total Waste (Wet Wt.) | Total Waste (Dry Wt.) | Total Potentially Hazardous Waste (Wet Wt.) | Total Potentially Hazardous Waste (Dry Wt.) | Total Hazardous Constituents (Dry Wt.) Flammable Solvents | Total Hazardous Constituents (Dry Wt.) Heavy Metals | Total Hazardous Constituents (Dry Wt.) Fluorides | Total Hazardous Constituents (Dry Wt.) Oils |
|---|---|---|---|---|---|---|---|---|---|
| ALABAMA | IV | 37. | 37. | 16. | 16. | 0. | .000 | 0. | .004 |
| ALASKA | X | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| ARIZONA | IX | 111. | 111. | 48. | 48. | 0. | .000 | 0. | .012 |
| ARKANSAS | VI | 54. | 54. | 23. | 23. | 0. | .000 | 0. | .006 |
| CALIFORNIA | IX | 1814. | 1814. | 777. | 777. | 0. | .008 | 0. | .189 |
| COLORADO | VIII | 38. | 38. | 16. | 16. | 0. | .000 | 0. | .004 |
| CONNECTICUT | I | 247. | 247. | 106. | 106. | 0. | .001 | 0. | .026 |
| DISTRICT OF COLUMBIA | III | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| DELAWARE | III | 29. | 29. | 12. | 12. | 0. | .000 | 0. | .003 |
| FLORIDA | IV | 371. | 371. | 159. | 159. | 0. | .002 | 0. | .039 |
| GEORGIA | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| HAWAII | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| IDAHO | X | 69. | 69. | 30. | 30. | 0. | .000 | 0. | .007 |
| ILLINOIS | V | 710. | 710. | 304. | 304. | 0. | .003 | 0. | .074 |
| INDIANA | V | 408. | 408. | 175. | 175. | 0. | .002 | 0. | .043 |
| IOWA | VII | 42. | 42. | 18. | 18. | 0. | .000 | 0. | .004 |
| KANSAS | VII | 16. | 16. | 7. | 7. | 0. | .000 | 0. | .002 |
| KENTUCKY | IV | 76. | 76. | 32. | 32. | 0. | .000 | 0. | .008 |
| LOUISIANA | VI | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MAINE | I | 65. | 65. | 28. | 28. | 0. | .000 | 0. | .007 |
| MARYLAND | III | 37. | 37. | 16. | 16. | 0. | .000 | 0. | .004 |
| MASSACHUSETTS | I | 719. | 719. | 308. | 308. | 0. | .003 | 0. | .075 |
| MICHIGAN | V | 71. | 71. | 30. | 30. | 0. | .000 | 0. | .007 |
| MINNESOTA | V | 184. | 184. | 79. | 79. | 0. | .001 | 0. | .019 |
| MISSISSIPPI | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MISSOURI | VII | 44. | 44. | 19. | 19. | 0. | .000 | 0. | .005 |
| MONTANA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEBRASKA | VII | 48. | 48. | 21. | 21. | 0. | .000 | 0. | .005 |
| NEVADA | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW HAMPSHIRE | I | 93. | 93. | 40. | 40. | 0. | .000 | 0. | .010 |
| NEW JERSEY | II | 600. | 600. | 257. | 257. | 0. | .003 | 0. | .063 |
| NEW MEXICO | VI | 69. | 69. | 30. | 30. | 0. | .000 | 0. | .007 |
| NEW YORK | II | 2392. | 2392. | 1025. | 1025. | 0. | .010 | 0. | .249 |
| NORTH CAROLINA | IV | 99. | 99. | 43. | 43. | 0. | .000 | 0. | .010 |
| NORTH DAKOTA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| OHIO | V | 362. | 362. | 155. | 155. | 0. | .002 | 0. | .038 |
| OKLAHOMA | VI | 30. | 30. | 13. | 13. | 0. | .000 | 0. | .003 |
| OREGON | X | 19. | 19. | 8. | 8. | 0. | .000 | 0. | .002 |
| PENNSYLVANIA | III | 926. | 926. | 397. | 397. | 0. | .004 | 0. | .097 |
| RHODE ISLAND | I | 69. | 69. | 30. | 30. | 0. | .000 | 0. | .007 |
| SOUTH CAROLINA | IV | 67. | 67. | 29. | 29. | 0. | .000 | 0. | .007 |
| SOUTH DAKOTA | VIII | 44. | 44. | 19. | 19. | 0. | .000 | 0. | .005 |
| TENNESSEE | IV | 26. | 26. | 11. | 11. | 0. | .000 | 0. | .003 |
| TEXAS | VI | 362. | 362. | 155. | 155. | 0. | .002 | 0. | .038 |
| UTAH | VIII | 86. | 86. | 37. | 37. | 0. | .000 | 0. | .009 |
| VERMONT | I | 27. | 27. | 12. | 12. | 0. | .000 | 0. | .003 |
| VIRGINIA | III | 188. | 188. | 80. | 80. | 0. | .001 | 0. | .020 |
| WASHINGTON | X | 16. | 16. | 7. | 7. | 0. | .000 | 0. | .002 |
| WEST VIRGINIA | III | 24. | 24. | 10. | 10. | 0. | .000 | 0. | .003 |
| WISCONSIN | V | 90. | 90. | 38. | 38. | 0. | .000 | 0. | .009 |
| WYOMING | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| TOTALS |  | 10780. | 10780. | 4620. | 4620. | 0. | .046 | 0. | 1.124 |
| REGION I |  | 1221. | 1221. | 523. | 523. | 0. | .005 | 0. | .127 |
| II |  | 2992. | 2992. | 1282. | 1282. | 0. | .013 | 0. | .312 |
| III |  | 1203. | 1203. | 516. | 516. | 0. | .005 | 0. | .125 |
| IV |  | 676. | 676. | 290. | 290. | 0. | .003 | 0. | .070 |
| V |  | 1825. | 1825. | 782. | 782. | 0. | .008 | 0. | .190 |
| VI |  | 516. | 516. | 221. | 221. | 0. | .002 | 0. | .054 |
| VII |  | 151. | 151. | 65. | 65. | 0. | .001 | 0. | .016 |
| VIII |  | 168. | 168. | 72. | 72. | 0. | .001 | 0. | .018 |
| IX |  | 1926. | 1926. | 825. | 825. | 0. | .008 | 0. | .201 |
| X |  | 104. | 104. | 45. | 45. | 0. | .000 | 0. | .011 |

## ELECTRONIC COMPONENTS MANUFACTURING
## SIC 367
## PROCESS WASTE GENERATION — NON-HALOGENATED SOLVENTS
## 1975 State and EPA Region Totals
## (kkg/year)

| State | EPA Region | Total Waste (Wet Wt.) | Total Waste (Dry Wt.) | Total Potentially Hazardous Waste (Wet Wt.) | Total Potentially Hazardous Waste (Dry Wt.) | Total Hazardous Constituents (Dry Wt.) Flammable Solvents | Heavy Metals | Fluorides | Oils |
|---|---|---|---|---|---|---|---|---|---|
| ALABAMA | IV | 54. | 54. | 54. | 54. | 48. | .000 | 0. | .005 |
| ALASKA | X | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| ARIZONA | IX | 159. | 159. | 159. | 159. | 143. | .001 | 0. | .016 |
| ARKANSAS | VI | 76. | 76. | 76. | 76. | 69. | .000 | 0. | .008 |
| CALIFORNIA | IX | 2592. | 2592. | 2592. | 2592. | 2332. | .010 | 0. | .259 |
| COLORADO | VIII | 55. | 55. | 55. | 55. | 49. | .000 | 0. | .005 |
| CONNECTICUT | I | 353. | 353. | 353. | 353. | 318. | .001 | 0. | .035 |
| DISTRICT OF COLUMBIA | III | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| DELAWARE | III | 41. | 41. | 41. | 41. | 37. | .000 | 0. | .004 |
| FLORIDA | IV | 529. | 529. | 529. | 529. | 476. | .002 | 0. | .053 |
| GEORGIA | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| HAWAII | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| IDAHO | X | 99. | 99. | 99. | 99. | 89. | .000 | 0. | .010 |
| ILLINOIS | V | 1014. | 1014. | 1014. | 1014. | 913. | .004 | 0. | .101 |
| INDIANA | V | 582. | 582. | 582. | 582. | 524. | .002 | 0. | .058 |
| IOWA | VII | 60. | 60. | 60. | 60. | 54. | .000 | 0. | .006 |
| KANSAS | VII | 23. | 23. | 23. | 23. | 21. | .000 | 0. | .002 |
| KENTUCKY | IV | 108. | 108. | 108. | 108. | 97. | .000 | 0. | .011 |
| LOUISIANA | VI | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MAINE | I | 92. | 92. | 92. | 92. | 83. | .000 | 0. | .009 |
| MARYLAND | III | 52. | 52. | 52. | 52. | 47. | .000 | 0. | .005 |
| MASSACHUSETTS | I | 1029. | 1028. | 1028. | 1028. | 925. | .004 | 0. | .103 |
| MICHIGAN | V | 102. | 102. | 102. | 102. | 91. | .000 | 0. | .010 |
| MINNESOTA | V | 263. | 263. | 263. | 263. | 236. | .001 | 0. | .026 |
| MISSISSIPPI | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MISSOURI | VII | 63. | 63. | 63. | 63. | 57. | .000 | 0. | .006 |
| MONTANA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEBRASKA | VII | 69. | 69. | 69. | 69. | 62. | .000 | 0. | .007 |
| NEVADA | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW HAMPSHIRE | I | 133. | 133. | 133. | 133. | 120. | .001 | 0. | .013 |
| NEW JERSEY | II | 858. | 858. | 858. | 858. | 772. | .003 | 0. | .086 |
| NEW MEXICO | VI | 99. | 99. | 99. | 99. | 89. | .000 | 0. | .010 |
| NEW YORK | II | 3417. | 3417. | 3417. | 3417. | 3075. | .014 | 0. | .342 |
| NORTH CAROLINA | IV | 142. | 142. | 142. | 142. | 128. | .001 | 0. | .014 |
| NORTH DAKOTA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| OHIO | V | 517. | 517. | 517. | 517. | 466. | .002 | 0. | .052 |
| OKLAHOMA | VI | 43. | 43. | 43. | 43. | 39. | .000 | 0. | .004 |
| OREGON | X | 27. | 27. | 27. | 27. | 24. | .000 | 0. | .003 |
| PENNSYLVANIA | III | 1322. | 1322. | 1322. | 1322. | 1190. | .005 | 0. | .132 |
| RHODE ISLAND | I | 99. | 99. | 99. | 99. | 89. | .000 | 0. | .010 |
| SOUTH CAROLINA | IV | 95. | 96. | 96. | 96. | 86. | .000 | 0. | .010 |
| SOUTH DAKOTA | VIII | 62. | 62. | 62. | 62. | 56. | .000 | 0. | .006 |
| TENNESSEE | IV | 37. | 37. | 37. | 37. | 33. | .000 | 0. | .004 |
| TEXAS | VI | 518. | 518. | 518. | 518. | 466. | .002 | 0. | .052 |
| UTAH | VIII | 123. | 123. | 123. | 123. | 111. | .000 | 0. | .012 |
| VERMONT | I | 38. | 38. | 38. | 38. | 35. | .000 | 0. | .004 |
| VIRGINIA | III | 268. | 268. | 268. | 268. | 241. | .001 | 0. | .027 |
| WASHINGTON | X | 23. | 23. | 23. | 23. | 21. | .000 | 0. | .002 |
| WEST VIRGINIA | III | 35. | 35. | 35. | 35. | 31. | .000 | 0. | .003 |
| WISCONSIN | V | 128. | 128. | 128. | 128. | 115. | .001 | 0. | .013 |
| WYOMING | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| TOTALS |  | 15400. | 15400. | 15400. | 15400. | 13860. | .062 | 0. | 1.540 |
| REGION I |  | 1744. | 1744. | 1744. | 1744. | 1570. | .007 | 0. | .174 |
| II |  | 4274. | 4274. | 4274. | 4274. | 3847. | .017 | 0. | .427 |
| III |  | 1718. | 1719. | 1718. | 1718. | 1547. | .007 | 0. | .172 |
| IV |  | 965. | 965. | 965. | 965. | 869. | .004 | 0. | .097 |
| V |  | 2607. | 2607. | 2607. | 2607. | 2346. | .010 | 0. | .261 |
| VI |  | 737. | 737. | 737. | 737. | 663. | .003 | 0. | .074 |
| VII |  | 215. | 215. | 215. | 215. | 194. | .001 | 0. | .022 |
| VIII |  | 240. | 240. | 240. | 240. | 216. | .001 | 0. | .024 |
| IX |  | 2751. | 2751. | 2751. | 2751. | 2476. | .011 | 0. | .275 |
| X |  | 149. | 149. | 149. | 149. | 134. | .001 | 0. | .015 |

ELECTRONIC COMPONENTS MANUFACTURING
SIC 367
PROCESS WASTE GENERATION — WASTEWATER TREATMENT SLUDGES
1975 State and EPA Region Totals
(kkg/year)

| State | EPA Region | Total Waste | | Total Potentially Hazardous Waste | | Total Hazardous Constituents (Dry Wt.) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | (Wet Wt.) | (Dry Wt.) | (Wet Wt.) | (Dry Wt.) | Flammable Solvents | Heavy Metals | Fluorides | Oils |
| ALABAMA | IV | 96. | 19. | 96. | 19. | 0. | .166 | 0. | 0. |
| ALASKA | X | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| ARIZONA | IX | 286. | 56. | 286. | 56. | 0. | .493 | 0. | 0. |
| ARKANSAS | VI | 138. | 27. | 138. | 27. | 0. | .237 | 0. | 0. |
| CALIFORNIA | IX | 4665. | 907. | 4665. | 907. | 0. | 8.034 | 5. | 0. |
| COLORADO | VIII | 98. | 19. | 98. | 19. | 0. | .169 | 0. | 0. |
| CONNECTICUT | I | 636. | 124. | 636. | 124. | 0. | 1.095 | 1. | 0. |
| DISTRICT OF COLUMBIA | III | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| DELAWARE | III | 74. | 14. | 74. | 14. | 0. | .127 | 0. | 0. |
| FLORIDA | IV | 953. | 185. | 953. | 185. | 0. | 1.641 | 1. | 0. |
| GEORGIA | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| HAWAII | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| IDAHO | X | 178. | 35. | 178. | 35. | 0. | .307 | 0. | 0. |
| ILLINOIS | V | 1826. | 355. | 1826. | 355. | 0. | 3.144 | 2. | 0. |
| INDIANA | V | 1048. | 204. | 1048. | 204. | 0. | 1.806 | 1. | 0. |
| IOWA | VII | 109. | 21. | 109. | 21. | 0. | .187 | 0. | 0. |
| KANSAS | VII | 41. | 8. | 41. | 8. | 0. | .071 | 0. | 0. |
| KENTUCKY | IV | 195. | 38. | 195. | 38. | 0. | .335 | 0. | 0. |
| LOUISIANA | VI | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MAINE | I | 166. | 32. | 166. | 32. | 0. | .286 | 0. | 0. |
| MARYLAND | III | 94. | 18. | 94. | 18. | 0. | .162 | 0. | 0. |
| MASSACHUSETTS | I | 1850. | 360. | 1850. | 360. | 0. | 3.185 | 2. | 0. |
| MICHIGAN | V | 183. | 36. | 183. | 36. | 0. | .315 | 0. | 0. |
| MINNESOTA | V | 473. | 92. | 473. | 92. | 0. | .814 | 0. | 0. |
| MISSISSIPPI | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MISSOURI | VII | 114. | 22. | 114. | 22. | 0. | .196 | 0. | 0. |
| MONTANA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEBRASKA | VII | 123. | 24. | 123. | 24. | 0. | .213 | 0. | 0. |
| NEVADA | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW HAMPSHIRE | I | 240. | 47. | 240. | 47. | 0. | .414 | 0. | 0. |
| NEW JERSEY | II | 1544. | 300. | 1544. | 300. | 0. | 2.658 | 2. | 0. |
| NEW MEXICO | VI | 178. | 35. | 178. | 35. | 0. | .307 | 0. | 0. |
| NEW YORK | II | 6150. | 1196. | 6150. | 1196. | 0. | 10.593 | 6. | 0. |
| NORTH CAROLINA | IV | 255. | 50. | 255. | 50. | 0. | .439 | 0. | 0. |
| NORTH DAKOTA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| OHIO | V | 931. | 181. | 931. | 181. | 0. | 1.604 | 1. | 0. |
| OKLAHOMA | VI | 78. | 15. | 78. | 15. | 0. | .134 | 0. | 0. |
| OREGON | X | 48. | 9. | 48. | 9. | 0. | .082 | 0. | 0. |
| PENNSYLVANIA | III | 2380. | 463. | 2380. | 463. | 0. | 4.099 | 2. | 0. |
| RHODE ISLAND | I | 179. | 35. | 179. | 35. | 0. | .307 | 0. | 0. |
| SOUTH CAROLINA | IV | 173. | 34. | 173. | 34. | 0. | .298 | 0. | 0. |
| SOUTH DAKOTA | VIII | 112. | 22. | 112. | 22. | 0. | .193 | 0. | 0. |
| TENNESSEE | IV | 66. | 13. | 66. | 13. | 0. | .113 | 0. | 0. |
| TEXAS | VI | 932. | 181. | 932. | 181. | 0. | 1.605 | 1. | 0. |
| UTAH | VIII | 221. | 43. | 221. | 43. | 0. | .381 | 0. | 0. |
| VERMONT | I | 69. | 13. | 69. | 13. | 0. | .119 | 0. | 0. |
| VIRGINIA | III | 483. | 94. | 483. | 94. | 0. | .832 | 0. | 0. |
| WASHINGTON | X | 42. | 8. | 42. | 8. | 0. | .073 | 0. | 0. |
| WEST VIRGINIA | III | 62. | 12. | 62. | 12. | 0. | .107 | 0. | 0. |
| WISCONSIN | V | 231. | 45. | 231. | 45. | 0. | .397 | 0. | 0. |
| WYOMING | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| TOTALS | | 27720. | 5390. | 27720. | 5390. | 0. | 47.740 | 28. | 0. |
| REGION I | | 3139. | 610. | 3139. | 610. | 0. | 5.406 | 3. | 0. |
| II | | 7694. | 1496. | 7694. | 1496. | 0. | 13.251 | 8. | 0. |
| III | | 3093. | 601. | 3093. | 601. | 0. | 5.327 | 3. | 0. |
| IV | | 1738. | 338. | 1738. | 338. | 0. | 2.992 | 2. | 0. |
| V | | 4692. | 912. | 4692. | 912. | 0. | 8.080 | 5. | 0. |
| VI | | 1326. | 258. | 1326. | 258. | 0. | 2.283 | 1. | 0. |
| VII | | 387. | 75. | 387. | 75. | 0. | .667 | 0. | 0. |
| VIII | | 432. | 84. | 432. | 84. | 0. | .743 | 0. | 0. |
| IX | | 4951. | 963. | 4951. | 963. | 0. | 8.527 | 5. | 0. |
| X | | 268. | 52. | 268. | 52. | 0. | .462 | 0. | 0. |

### ELECTRONIC COMPONENTS MANUFACTURING
### SIC 367
### PROCESS WASTE GENERATION — PLASTICS
### 1975 State and EPA Region Totals
### (kkg/year)

| State | EPA Region | Total Waste |  | Total Potentially Hazardous Waste |  | Total Hazardous Constituents (Dry Wt.) |  |  |  |
|---|---|---|---|---|---|---|---|---|---|
|  |  | (Wet Wt.) | (Dry Wt.) | (Wet Wt.) | (Dry Wt.) | Flammable Solvents | Heavy Metals | Fluorides | Oils |
| ALABAMA | IV | 16. | 16. | 0. | 0. | 0. | 0. | 0. | 0. |
| ALASKA | X | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| ARIZONA | IX | 48. | 48. | 0. | 0. | 0. | 0. | 0. | 0. |
| ARKANSAS | VI | 23. | 23. | 0. | 0. | 0. | 0. | 0. | 0. |
| CALIFORNIA | IX | 777. | 777. | 0. | 0. | 0. | 0. | 0. | 0. |
| COLORADO | VIII | 16. | 16. | 0. | 0. | 0. | 0. | 0. | 0. |
| CONNECTICUT | I | 106. | 106. | 0. | 0. | 0. | 0. | 0. | 0. |
| DISTRICT OF COLUMBIA | III | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| DELAWARE | III | 12. | 12. | 0. | 0. | 0. | 0. | 0. | 0. |
| FLORIDA | IV | 159. | 159. | 0. | 0. | 0. | 0. | 0. | 0. |
| GEORGIA | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| HAWAII | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| IDAHO | X | 30. | 30. | 0. | 0. | 0. | 0. | 0. | 0. |
| ILLINOIS | V | 304. | 304. | 0. | 0. | 0. | 0. | 0. | 0. |
| INDIANA | V | 175. | 175. | 0. | 0. | 0. | 0. | 0. | 0. |
| IOWA | VII | 18. | 18. | 0. | 0. | 0. | 0. | 0. | 0. |
| KANSAS | VII | 7. | 7. | 0. | 0. | 0. | 0. | 0. | 0. |
| KENTUCKY | IV | 32. | 32. | 0. | 0. | 0. | 0. | 0. | 0. |
| LOUISIANA | VI | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MAINE | I | 28. | 28. | 0. | 0. | 0. | 0. | 0. | 0. |
| MARYLAND | III | 16. | 16. | 0. | 0. | 0. | 0. | 0. | 0. |
| MASSACHUSETTS | I | 308. | 308. | 0. | 0. | 0. | 0. | 0. | 0. |
| MICHIGAN | V | 30. | 30. | 0. | 0. | 0. | 0. | 0. | 0. |
| MINNESOTA | V | 79. | 79. | 0. | 0. | 0. | 0. | 0. | 0. |
| MISSISSIPPI | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MISSOURI | VII | 19. | 19. | 0. | 0. | 0. | 0. | 0. | 0. |
| MONTANA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEBRASKA | VII | 21. | 21. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEVADA | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW HAMPSHIRE | I | 40. | 40. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW JERSEY | II | 257. | 257. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW MEXICO | VI | 30. | 30. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW YORK | II | 1025. | 1025. | 0. | 0. | 0. | 0. | 0. | 0. |
| NORTH CAROLINA | IV | 43. | 43. | 0. | 0. | 0. | 0. | 0. | 0. |
| NORTH DAKOTA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| OHIO | V | 155. | 155. | 0. | 0. | 0. | 0. | 0. | 0. |
| OKLAHOMA | VI | 13. | 13. | 0. | 0. | 0. | 0. | 0. | 0. |
| OREGON | X | 8. | 8. | 0. | 0. | 0. | 0. | 0. | 0. |
| PENNSYLVANIA | III | 397. | 397. | 0. | 0. | 0. | 0. | 0. | 0. |
| RHODE ISLAND | I | 30. | 30. | 0. | 0. | 0. | 0. | 0. | 0. |
| SOUTH CAROLINA | IV | 29. | 29. | 0. | 0. | 0. | 0. | 0. | 0. |
| SOUTH DAKOTA | VIII | 19. | 19. | 0. | 0. | 0. | 0. | 0. | 0. |
| TENNESSEE | IV | 11. | 11. | 0. | 0. | 0. | 0. | 0. | 0. |
| TEXAS | VI | 155. | 155. | 0. | 0. | 0. | 0. | 0. | 0. |
| UTAH | VIII | 37. | 37. | 0. | 0. | 0. | 0. | 0. | 0. |
| VERMONT | I | 12. | 12. | 0. | 0. | 0. | 0. | 0. | 0. |
| VIRGINIA | III | 80. | 80. | 0. | 0. | 0. | 0. | 0. | 0. |
| WASHINGTON | X | 7. | 7. | 0. | 0. | 0. | 0. | 0. | 0. |
| WEST VIRGINIA | III | 10. | 10. | 0. | 0. | 0. | 0. | 0. | 0. |
| WISCONSIN | V | 38. | 38. | 0. | 0. | 0. | 0. | 0. | 0. |
| WYOMING | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| TOTALS |  | 4620. | 4620. | 0. | 0. | 0. | 0. | 0. | 0. |
| REGION I |  | 523. | 523. | 0. | 0. | 0. | 0. | 0. | 0. |
| II |  | 1292. | 1282. | 0. | 0. | 0. | 0. | 0. | 0. |
| III |  | 516. | 516. | 0. | 0. | 0. | 0. | 0. | 0. |
| IV |  | 290. | 290. | 0. | 0. | 0. | 0. | 0. | 0. |
| V |  | 782. | 782. | 0. | 0. | 0. | 0. | 0. | 0. |
| VI |  | 221. | 221. | 0. | 0. | 0. | 0. | 0. | 0. |
| VII |  | 65. | 65. | 0. | 0. | 0. | 0. | 0. | 0. |
| VIII |  | 72. | 72. | 0. | 0. | 0. | 0. | 0. | 0. |
| IX |  | 825. | 825. | 0. | 0. | 0. | 0. | 0. | 0. |
| X |  | 45. | 45. | 0. | 0. | 0. | 0. | 0. | 0. |

## ELECTRONIC COMPONENTS MANUFACTURING
## SIC 367
## PROCESS WASTE GENERATION — LUBRICATING & HYDRAULIC OILS
## 1973 State and EPA Region Totals
## (kkg/year)

| State | EPA Region | Total Waste | | Total Potentially Hazardous Waste | | Total Hazardous Constituents (Dry Wt.) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Wet Wt. | Dry Wt. | Wet Wt. | Dry Wt. | Flammable Solvents | Heavy Metals | Fluorides | Oils |
| ALABAMA | IV | 5. | 1. | 5. | 1. | 0. | .002 | 0. | .278 |
| ALASKA | X | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| ARIZONA | IX | 16. | 2. | 16. | 2. | 0. | .005 | 0. | .828 |
| ARKANSAS | VI | 8. | 1. | 8. | 1. | 0. | .002 | 0. | .397 |
| CALIFORNIA | IX | 259. | 31. | 259. | 31. | 0. | .078 | 0. | 13.476 |
| COLORADO | VIII | 5. | 1. | 5. | 1. | 0. | .002 | 0. | .284 |
| CONNECTICUT | I | 35. | 4. | 35. | 4. | 0. | .011 | 0. | 1.836 |
| DISTRICT OF COLUMBIA | III | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| DELAWARE | III | 4. | 0. | 4. | 0. | 0. | .001 | 0. | .213 |
| FLORIDA | IV | 53. | 6. | 53. | 6. | 0. | .016 | 0. | 2.753 |
| GEORGIA | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| HAWAII | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| IDAHO | X | 10. | 1. | 10. | 1. | 0. | .003 | 0. | .515 |
| ILLINOIS | V | 101. | 12. | 101. | 12. | 0. | .030 | 0. | 5.274 |
| INDIANA | V | 58. | 7. | 58. | 7. | 0. | .017 | 0. | 3.029 |
| IOWA | VII | 6. | 1. | 6. | 1. | 0. | .002 | 0. | .314 |
| KANSAS | VII | 2. | 0. | 2. | 0. | 0. | .001 | 0. | .119 |
| KENTUCKY | IV | 11. | 1. | 11. | 1. | 0. | .003 | 0. | .562 |
| LOUISIANA | VI | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MAINE | I | 9. | 1. | 9. | 1. | 0. | .003 | 0. | .479 |
| MARYLAND | III | 5. | 1. | 5. | 1. | 0. | .002 | 0. | .272 |
| MASSACHUSETTS | I | 103. | 12. | 103. | 12. | 0. | .031 | 0. | 5.343 |
| MICHIGAN | V | 10. | 1. | 10. | 1. | 0. | .003 | 0. | .528 |
| MINNESOTA | V | 26. | 3. | 26. | 3. | 0. | .008 | 0. | 1.366 |
| MISSISSIPPI | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MISSOURI | VII | 6. | 1. | 6. | 1. | 0. | .002 | 0. | .329 |
| MONTANA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEBRASKA | VII | 7. | 1. | 7. | 1. | 0. | .002 | 0. | .357 |
| NEVADA | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW HAMPSHIRE | I | 13. | 2. | 13. | 2. | 0. | .004 | 0. | .694 |
| NEW JERSEY | II | 86. | 10. | 86. | 10. | 0. | .026 | 0. | 4.459 |
| NEW MEXICO | VI | 10. | 1. | 10. | 1. | 0. | .003 | 0. | .515 |
| NEW YORK | II | 342. | 41. | 342. | 41. | 0. | .103 | 0. | 17.768 |
| NORTH CAROLINA | IV | 14. | 2. | 14. | 2. | 0. | .004 | 0. | .737 |
| NORTH DAKOTA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| OHIO | V | 52. | 6. | 52. | 6. | 0. | .016 | 0. | 2.690 |
| OKLAHOMA | VI | 4. | 1. | 4. | 1. | 0. | .001 | 0. | .226 |
| OREGON | X | 3. | 0. | 3. | 0. | 0. | .001 | 0. | .138 |
| PENNSYLVANIA | III | 132. | 16. | 132. | 16. | 0. | .040 | 0. | 6.876 |
| RHODE ISLAND | I | 10. | 1. | 10. | 1. | 0. | .003 | 0. | .516 |
| SOUTH CAROLINA | IV | 10. | 1. | 10. | 1. | 0. | .003 | 0. | .499 |
| SOUTH DAKOTA | VIII | 6. | 1. | 6. | 1. | 0. | .002 | 0. | .324 |
| TENNESSEE | IV | 4. | 0. | 4. | 0. | 0. | .001 | 0. | .190 |
| TEXAS | VI | 52. | 6. | 52. | 6. | 0. | .016 | 0. | 2.692 |
| UTAH | VIII | 12. | 1. | 12. | 1. | 0. | .004 | 0. | .639 |
| VERMONT | I | 4. | 0. | 4. | 0. | 0. | .001 | 0. | .200 |
| VIRGINIA | III | 27. | 3. | 27. | 3. | 0. | .008 | 0. | 1.395 |
| WASHINGTON | X | 2. | 0. | 2. | 0. | 0. | .001 | 0. | .122 |
| WEST VIRGINIA | III | 3. | 0. | 3. | 0. | 0. | .001 | 0. | .180 |
| WISCONSIN | V | 13. | 2. | 13. | 2. | 0. | .004 | 0. | .667 |
| WYOMING | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| TOTALS | | 1540. | 185. | 1540. | 185. | 0. | .462 | 0. | 80.080 |
| REGION I | | 174. | 21. | 174. | 21. | 0. | .052 | 0. | 9.069 |
| II | | 427. | 51. | 427. | 51. | 0. | .128 | 0. | 22.227 |
| III | | 172. | 21. | 172. | 21. | 0. | .052 | 0. | 8.936 |
| IV | | 97. | 12. | 97. | 12. | 0. | .029 | 0. | 5.020 |
| V | | 261. | 31. | 261. | 31. | 0. | .078 | 0. | 13.554 |
| VI | | 74. | 9. | 74. | 9. | 0. | .022 | 0. | 3.830 |
| VII | | 22. | 3. | 22. | 3. | 0. | .006 | 0. | 1.119 |
| VIII | | 24. | 3. | 24. | 3. | 0. | .007 | 0. | 1.247 |
| IX | | 275. | 33. | 275. | 33. | 0. | .083 | 0. | 14.304 |
| X | | 15. | 2. | 15. | 2. | 0. | .004 | 0. | .775 |

# ELECTRONIC COMPONENTS MANUFACTURING
## SIC 367
## PROCESS WASTE GENERATION — PAINT WASTES
## 1975 State and EPA Region Totals
## (kkg/year)

| State | EPA Region | Total Waste | | Total Potentially Hazardous Waste | | Total Hazardous Constituents (Dry Wt.) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | (Wet Wt.) | (Dry Wt.) | (Wet Wt.) | (Dry Wt.) | Flammable Solvents | Heavy Metals | Fluorides | Oils |
| ALABAMA | IV | 1. | 1. | 1. | 1. | 0. | .000 | 0. | 0. |
| ALASKA | X | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| ARIZONA | IX | 2. | 2. | 2. | 2. | 1. | .000 | 0. | 0. |
| ARKANSAS | VI | 1. | 1. | 1. | 1. | 0. | .000 | 0. | 0. |
| CALIFORNIA | IX | 34. | 34. | 34. | 34. | 17. | .008 | 0. | 0. |
| COLORADO | VIII | 1. | 1. | 1. | 1. | 0. | .000 | 0. | 0. |
| CONNECTICUT | I | 5. | 5. | 5. | 5. | 2. | .001 | 0. | 0. |
| DISTRICT OF COLUMBIA | III | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| DELAWARE | III | 1. | 1. | 1. | 1. | 0. | .000 | 0. | 0. |
| FLORIDA | IV | 7. | 7. | 7. | 7. | 3. | .002 | 0. | 0. |
| GEORGIA | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| HAWAII | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| IDAHO | X | 1. | 1. | 1. | 1. | 1. | .000 | 0. | 0. |
| ILLINOIS | V | 13. | 13. | 13. | 13. | 7. | .003 | 0. | 0. |
| INDIANA | V | 8. | 8. | 8. | 8. | 4. | .002 | 0. | 0. |
| IOWA | VII | 1. | 1. | 1. | 1. | 0. | .000 | 0. | 0. |
| KANSAS | VII | 0. | 0. | 0. | 0. | 0. | .000 | 0. | 0. |
| KENTUCKY | IV | 1. | 1. | 1. | 1. | 1. | .000 | 0. | 0. |
| LOUISIANA | VI | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MAINE | I | 1. | 1. | 1. | 1. | 1. | .000 | 0. | 0. |
| MARYLAND | III | 1. | 1. | 1. | 1. | 0. | .000 | 0. | 0. |
| MASSACHUSETTS | I | 13. | 13. | 13. | 13. | 7. | .003 | 0. | 0. |
| MICHIGAN | V | 1. | 1. | 1. | 1. | 1. | .000 | 0. | 0. |
| MINNESOTA | V | 3. | 3. | 3. | 3. | 2. | .001 | 0. | 0. |
| MISSISSIPPI | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MISSOURI | VII | 1. | 1. | 1. | 1. | 0. | .000 | 0. | 0. |
| MONTANA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEBRASKA | VII | 1. | 1. | 1. | 1. | 0. | .000 | 0. | 0. |
| NEVADA | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW HAMPSHIRE | I | 2. | 2. | 2. | 2. | 1. | .000 | 0. | 0. |
| NEW JERSEY | II | 11. | 11. | 11. | 11. | 6. | .003 | 0. | 0. |
| NEW MEXICO | VI | 1. | 1. | 1. | 1. | 1. | .000 | 0. | 0. |
| NEW YORK | II | 44. | 44. | 44. | 44. | 22. | .010 | 0. | 0. |
| NORTH CAROLINA | IV | 2. | 2. | 2. | 2. | 1. | .000 | 0. | 0. |
| NORTH DAKOTA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| OHIO | V | 7. | 7. | 7. | 7. | 3. | .002 | 0. | 0. |
| OKLAHOMA | VI | 1. | 1. | 1. | 1. | 0. | .000 | 0. | 0. |
| OREGON | X | 0. | 0. | 0. | 0. | 0. | .000 | 0. | 0. |
| PENNSYLVANIA | III | 17. | 17. | 17. | 17. | 9. | .004 | 0. | 0. |
| RHODE ISLAND | I | 1. | 1. | 1. | 1. | 1. | .000 | 0. | 0. |
| SOUTH CAROLINA | IV | 1. | 1. | 1. | 1. | 1. | .000 | 0. | 0. |
| SOUTH DAKOTA | VIII | 1. | 1. | 1. | 1. | 0. | .000 | 0. | 0. |
| TENNESSEE | IV | 0. | 0. | 0. | 0. | 0. | .000 | 0. | 0. |
| TEXAS | VI | 7. | 7. | 7. | 7. | 3. | .002 | 0. | 0. |
| UTAH | VIII | 2. | 2. | 2. | 2. | 1. | .000 | 0. | 0. |
| VERMONT | I | 1. | 1. | 1. | 1. | 0. | .000 | 0. | 0. |
| VIRGINIA | III | 3. | 3. | 3. | 3. | 2. | .001 | 0. | 0. |
| WASHINGTON | X | 0. | 0. | 0. | 0. | 0. | .000 | 0. | 0. |
| WEST VIRGINIA | III | 0. | 0. | 0. | 0. | 0. | .000 | 0. | 0. |
| WISCONSIN | V | 2. | 2. | 2. | 2. | 1. | .000 | 0. | 0. |
| WYOMING | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| TOTALS | | 200. | 200. | 200. | 200. | 100. | .046 | 0. | 0. |
| REGION I | | 23. | 23. | 23. | 23. | 11. | .005 | 0. | 0. |
| II | | 56. | 56. | 56. | 56. | 28. | .013 | 0. | 0. |
| III | | 22. | 22. | 22. | 22. | 11. | .005 | 0. | 0. |
| IV | | 13. | 13. | 13. | 13. | 6. | .003 | 0. | 0. |
| V | | 34. | 34. | 34. | 34. | 17. | .008 | 0. | 0. |
| VI | | 10. | 10. | 10. | 10. | 5. | .002 | 0. | 0. |
| VII | | 3. | 3. | 3. | 3. | 1. | .001 | 0. | 0. |
| VIII | | 3. | 3. | 3. | 3. | 2. | .001 | 0. | 0. |
| IX | | 36. | 36. | 36. | 36. | 18. | .008 | 0. | 0. |
| X | | 2. | 2. | 2. | 2. | 1. | .000 | 0. | 0. |

## ELECTRONIC COMPONENTS MANUFACTURING
## SIC 367
## PROCESS WASTE GENERATION — HALOGENATED SOLVENTS
## 1977 State and EPA Region Totals
## (kkg/year)

| State | EPA Region | Total Waste | | Total Potentially Hazardous Waste | | Total Hazardous Constituents (Dry Wt.) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | (Wet Wt.) | (Dry Wt.) | (Wet Wt.) | (Dry Wt.) | Flammable Solvents | Heavy Metals | Fluorides | Oils |
| ALABAMA | IV | 48. | 48. | 21. | 21. | 0. | .000 | 0. | .005 |
| ALASKA | X | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| ARIZONA | IX | 143. | 143. | 64. | 64. | 0. | .001 | 0. | .015 |
| ARKANSAS | VI | 69. | 69. | 31. | 31. | 0. | .000 | 0. | .007 |
| CALIFORNIA | IX | 2332. | 2332. | 1037. | 1037. | 0. | .009 | 0. | .238 |
| COLORADO | VIII | 49. | 49. | 22. | 22. | 0. | .000 | 0. | .005 |
| CONNECTICUT | I | 318. | 318. | 141. | 141. | 0. | .001 | 0. | .032 |
| DISTRICT OF COLUMBIA | III | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| DELAWARE | III | 37. | 37. | 16. | 16. | 0. | .000 | 0. | .004 |
| FLORIDA | IV | 476. | 476. | 212. | 212. | 0. | .002 | 0. | .049 |
| GEORGIA | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| HAWAII | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| IDAHO | X | 89. | 89. | 40. | 40. | 0. | .000 | 0. | .009 |
| ILLINOIS | V | 913. | 913. | 406. | 406. | 0. | .004 | 0. | .093 |
| INDIANA | V | 524. | 524. | 233. | 233. | 0. | .002 | 0. | .054 |
| IOWA | VII | 54. | 54. | 24. | 24. | 0. | .000 | 0. | .006 |
| KANSAS | VII | 21. | 21. | 9. | 9. | 0. | .000 | 0. | .002 |
| KENTUCKY | IV | 97. | 97. | 43. | 43. | 0. | .000 | 0. | .010 |
| LOUISIANA | VI | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MAINE | I | 83. | 83. | 37. | 37. | 0. | .000 | 0. | .008 |
| MARYLAND | III | 47. | 47. | 21. | 21. | 0. | .000 | 0. | .005 |
| MASSACHUSETTS | I | 925. | 925. | 411. | 411. | 0. | .004 | 0. | .095 |
| MICHIGAN | V | 91. | 91. | 41. | 41. | 0. | .000 | 0. | .009 |
| MINNESOTA | V | 236. | 236. | 105. | 105. | 0. | .001 | 0. | .024 |
| MISSISSIPPI | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MISSOURI | VII | 57. | 57. | 25. | 25. | 0. | .000 | 0. | .006 |
| MONTANA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEBRASKA | VII | 62. | 62. | 27. | 27. | 0. | .000 | 0. | .006 |
| NEVADA | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW HAMPSHIRE | I | 120. | 120. | 53. | 53. | 0. | .000 | 0. | .012 |
| NEW JERSEY | II | 772. | 772. | 343. | 343. | 0. | .003 | 0. | .079 |
| NEW MEXICO | VI | 89. | 89. | 40. | 40. | 0. | .000 | 0. | .009 |
| NEW YORK | II | 3075. | 3075. | 1367. | 1367. | 0. | .012 | 0. | .314 |
| NORTH CAROLINA | IV | 128. | 128. | 57. | 57. | 0. | .001 | 0. | .013 |
| NORTH DAKOTA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| OHIO | V | 466. | 466. | 207. | 207. | 0. | .002 | 0. | .048 |
| OKLAHOMA | VI | 39. | 39. | 17. | 17. | 0. | .000 | 0. | .004 |
| OREGON | X | 24. | 24. | 11. | 11. | 0. | .000 | 0. | .002 |
| PENNSYLVANIA | III | 1190. | 1190. | 529. | 529. | 0. | .005 | 0. | .122 |
| RHODE ISLAND | I | 89. | 89. | 40. | 40. | 0. | .000 | 0. | .009 |
| SOUTH CAROLINA | IV | 86. | 86. | 38. | 38. | 0. | .000 | 0. | .009 |
| SOUTH DAKOTA | VIII | 56. | 56. | 25. | 25. | 0. | .000 | 0. | .006 |
| TENNESSEE | IV | 33. | 33. | 15. | 15. | 0. | .000 | 0. | .003 |
| TEXAS | VI | 466. | 466. | 207. | 207. | 0. | .002 | 0. | .048 |
| UTAH | VIII | 111. | 111. | 49. | 49. | 0. | .000 | 0. | .011 |
| VERMONT | I | 35. | 35. | 15. | 15. | 0. | .000 | 0. | .004 |
| VIRGINIA | III | 241. | 241. | 107. | 107. | 0. | .001 | 0. | .025 |
| WASHINGTON | X | 21. | 21. | 9. | 9. | 0. | .000 | 0. | .002 |
| WEST VIRGINIA | III | 31. | 31. | 14. | 14. | 0. | .000 | 0. | .003 |
| WISCONSIN | V | 115. | 115. | 51. | 51. | 0. | .000 | 0. | .012 |
| WYOMING | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| TOTALS | | 13860. | 13860. | 6160. | 6160. | 0. | .055 | 0. | 1.417 |
| REGION I | | 1570. | 1570. | 698. | 698. | 0. | .006 | 0. | .160 |
| II | | 3847. | 3847. | 1710. | 1710. | 0. | .015 | 0. | .393 |
| III | | 1547. | 1547. | 687. | 687. | 0. | .006 | 0. | .158 |
| IV | | 869. | 869. | 386. | 386. | 0. | .003 | 0. | .089 |
| V | | 2346. | 2346. | 1043. | 1043. | 0. | .009 | 0. | .240 |
| VI | | 663. | 663. | 295. | 295. | 0. | .003 | 0. | .068 |
| VII | | 194. | 194. | 86. | 86. | 0. | .001 | 0. | .020 |
| VIII | | 216. | 216. | 96. | 96. | 0. | .001 | 0. | .022 |
| IX | | 2476. | 2476. | 1100. | 1100. | 0. | .010 | 0. | .253 |
| X | | 134. | 134. | 60. | 60. | 0. | .001 | 0. | .014 |

## ELECTRONIC COMPONENTS MANUFACTURING
## SIC 367
## PROCESS WASTE GENERATION — NON-HALOGENATED SOLVENTS
## 1977 State and EPA Region Totals
## (kkg/year)

| State | EPA Region | Total Waste | | Total Potentially Hazardous Waste | | Total Hazardous Constituents (Dry Wt.) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Wet Wt. | Dry Wt. | Wet Wt. | Dry Wt. | Flammable Solvents | Heavy Metals | Fluorides | Oils |
| ALABAMA | IV | 64. | 64. | 64. | 64. | 59. | .000 | 0. | .006 |
| ALASKA | X | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| ARIZONA | IX | 191. | 191. | 191. | 191. | 175. | .001 | 0. | .019 |
| ARKANSAS | VI | 92. | 92. | 92. | 92. | 84. | .000 | 0. | .009 |
| CALIFORNIA | IX | 3110. | 3110. | 3110. | 3110. | 2851. | .013 | 0. | .311 |
| COLORADO | VIII | 65. | 65. | 65. | 65. | 60. | .000 | 0. | .007 |
| CONNECTICUT | I | 424. | 424. | 424. | 424. | 388. | .002 | 0. | .042 |
| DISTRICT OF COLUMBIA | III | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| DELAWARE | III | 49. | 49. | 49. | 49. | 45. | .000 | 0. | .005 |
| FLORIDA | IV | 635. | 635. | 635. | 635. | 582. | .003 | 0. | .064 |
| GEORGIA | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| HAWAII | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| IDAHO | X | 119. | 119. | 119. | 119. | 109. | .000 | 0. | .012 |
| ILLINOIS | V | 1217. | 1217. | 1217. | 1217. | 1116. | .005 | 0. | .122 |
| INDIANA | V | 699. | 699. | 699. | 699. | 641. | .003 | 0. | .070 |
| IOWA | VII | 72. | 72. | 72. | 72. | 66. | .000 | 0. | .007 |
| KANSAS | VII | 27. | 27. | 27. | 27. | 25. | .000 | 0. | .003 |
| KENTUCKY | IV | 130. | 130. | 130. | 130. | 119. | .001 | 0. | .013 |
| LOUISIANA | VI | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MAINE | I | 111. | 111. | 111. | 111. | 101. | .000 | 0. | .011 |
| MARYLAND | III | 63. | 63. | 63. | 63. | 58. | .000 | 0. | .006 |
| MASSACHUSETTS | I | 1233. | 1233. | 1233. | 1233. | 1130. | .005 | 0. | .123 |
| MICHIGAN | V | 122. | 122. | 122. | 122. | 112. | .001 | 0. | .012 |
| MINNESOTA | V | 315. | 315. | 315. | 315. | 289. | .001 | 0. | .032 |
| MISSISSIPPI | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MISSOURI | VII | 76. | 76. | 76. | 76. | 70. | .000 | 0. | .009 |
| MONTANA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEBRASKA | VII | 82. | 82. | 82. | 82. | 75. | .000 | 0. | .008 |
| NEVADA | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW HAMPSHIRE | I | 160. | 160. | 160. | 160. | 147. | .001 | 0. | .016 |
| NEW JERSEY | II | 1029. | 1029. | 1029. | 1029. | 943. | .004 | 0. | .103 |
| NEW MEXICO | VI | 119. | 119. | 119. | 119. | 109. | .000 | 0. | .012 |
| NEW YORK | II | 4100. | 4100. | 4100. | 4100. | 3759. | .017 | 0. | .410 |
| NORTH CAROLINA | IV | 170. | 170. | 170. | 170. | 156. | .001 | 0. | .017 |
| NORTH DAKOTA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| OHIO | V | 621. | 621. | 621. | 621. | 569. | .003 | 0. | .062 |
| OKLAHOMA | VI | 52. | 52. | 52. | 52. | 48. | .000 | 0. | .005 |
| OREGON | X | 32. | 32. | 32. | 32. | 29. | .000 | 0. | .003 |
| PENNSYLVANIA | III | 1587. | 1587. | 1587. | 1587. | 1455. | .007 | 0. | .159 |
| RHODE ISLAND | I | 119. | 119. | 119. | 119. | 109. | .000 | 0. | .012 |
| SOUTH CAROLINA | IV | 115. | 115. | 115. | 115. | 106. | .000 | 0. | .012 |
| SOUTH DAKOTA | VIII | 75. | 75. | 75. | 75. | 68. | .000 | 0. | .007 |
| TENNESSEE | IV | 44. | 44. | 44. | 44. | 40. | .000 | 0. | .004 |
| TEXAS | VI | 621. | 621. | 621. | 621. | 569. | .003 | 0. | .062 |
| UTAH | VIII | 148. | 148. | 148. | 148. | 135. | .001 | 0. | .015 |
| VERMONT | I | 46. | 46. | 46. | 46. | 42. | .000 | 0. | .005 |
| VIRGINIA | III | 322. | 322. | 322. | 322. | 295. | .001 | 0. | .032 |
| WASHINGTON | X | 28. | 28. | 28. | 28. | 26. | .000 | 0. | .003 |
| WEST VIRGINIA | III | 42. | 42. | 42. | 42. | 38. | .000 | 0. | .004 |
| WISCONSIN | V | 154. | 154. | 154. | 154. | 141. | .001 | 0. | .015 |
| WYOMING | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| TOTALS | | 18480. | 18480. | 18480. | 18480. | 16940. | .077 | 0. | 1.848 |
| REGION I | | 2093. | 2093. | 2093. | 2093. | 1918. | .009 | 0. | .209 |
| II | | 5129. | 5129. | 5129. | 5129. | 4702. | .021 | 0. | .513 |
| III | | 2062. | 2062. | 2062. | 2062. | 1890. | .009 | 0. | .206 |
| IV | | 1158. | 1158. | 1158. | 1158. | 1062. | .005 | 0. | .116 |
| V | | 3128. | 3128. | 3128. | 3128. | 2867. | .013 | 0. | .313 |
| VI | | 884. | 884. | 884. | 884. | 810. | .004 | 0. | .088 |
| VII | | 258. | 258. | 258. | 258. | 237. | .001 | 0. | .026 |
| VIII | | 288. | 288. | 288. | 288. | 264. | .001 | 0. | .029 |
| IX | | 3301. | 3301. | 3301. | 3301. | 3026. | .014 | 0. | .330 |
| X | | 179. | 179. | 179. | 179. | 164. | .001 | 0. | .018 |

## ELECTRONIC COMPONENTS MANUFACTURING
## SIC 367
## PROCESS WASTE GENERATION — WASTEWATER TREATMENT SLUDGES
## 1977 State and EPA Region Totals
## (kkg/year)

| State | EPA Region | Total Waste | | Total Potentially Hazardous Waste | | Total Hazardous Constituents (Dry Wt.) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | (Wet Wt.) | (Dry Wt.) | (Wet Wt.) | (Dry Wt.) | Flammable Solvents | Heavy Metals | Fluorides | Oils |
| ALABAMA | IV | 177. | 37. | 177. | 37. | 0. | .348 | 0. | 0. |
| ALASKA | X | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| ARIZONA | IX | 525. | 111. | 525. | 111. | 0. | 1.035 | 1. | 0. |
| ARKANSAS | VI | 252. | 54. | 252. | 54. | 0. | .497 | 0. | 0. |
| CALIFORNIA | IX | 8552. | 1814. | 8552. | 1814. | 0. | 16.845 | 10. | 0. |
| COLORADO | VIII | 180. | 38. | 180. | 38. | 0. | .355 | 0. | 0. |
| CONNECTICUT | I | 1165. | 247. | 1165. | 247. | 0. | 2.295 | 1. | 0. |
| DISTRICT OF COLUMBIA | III | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| DELAWARE | III | 135. | 29. | 135. | 29. | 0. | .266 | 0. | 0. |
| FLORIDA | IV | 1747. | 371. | 1747. | 371. | 0. | 3.441 | 2. | 0. |
| GEORGIA | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| HAWAII | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| IDAHO | X | 327. | 69. | 327. | 69. | 0. | .643 | 0. | 0. |
| ILLINOIS | V | 3347. | 710. | 3347. | 710. | 0. | 6.593 | 4. | 0. |
| INDIANA | V | 1922. | 408. | 1922. | 408. | 0. | 3.786 | 2. | 0. |
| IOWA | VII | 199. | 42. | 199. | 42. | 0. | .392 | 0. | 0. |
| KANSAS | VII | 76. | 16. | 76. | 16. | 0. | .149 | 0. | 0. |
| KENTUCKY | IV | 357. | 76. | 357. | 76. | 0. | .703 | 0. | 0. |
| LOUISIANA | VI | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MAINE | I | 304. | 65. | 304. | 65. | 0. | .599 | 0. | 0. |
| MARYLAND | III | 173. | 37. | 173. | 37. | 0. | .340 | 0. | 0. |
| MASSACHUSETTS | I | 3391. | 719. | 3391. | 719. | 0. | 6.679 | 4. | 0. |
| MICHIGAN | V | 335. | 71. | 335. | 71. | 0. | .661 | 0. | 0. |
| MINNESOTA | V | 867. | 184. | 867. | 184. | 0. | 1.708 | 1. | 0. |
| MISSISSIPPI | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MISSOURI | VII | 209. | 44. | 209. | 44. | 0. | .412 | 0. | 0. |
| MONTANA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEBRASKA | VII | 226. | 48. | 226. | 48. | 0. | .446 | 0. | 0. |
| NEVADA | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW HAMPSHIRE | I | 440. | 93. | 440. | 93. | 0. | .867 | 1. | 0. |
| NEW JERSEY | II | 2830. | 600. | 2830. | 600. | 0. | 5.574 | 3. | 0. |
| NEW MEXICO | VI | 327. | 69. | 327. | 69. | 0. | .643 | 0. | 0. |
| NEW YORK | II | 11276. | 2392. | 11276. | 2392. | 0. | 22.210 | 14. | 0. |
| NORTH CAROLINA | IV | 468. | 99. | 468. | 99. | 0. | .921 | 1. | 0. |
| NORTH DAKOTA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| OHIO | V | 1707. | 362. | 1707. | 362. | 0. | 3.363 | 2. | 0. |
| OKLAHOMA | VI | 143. | 30. | 143. | 30. | 0. | .282 | 0. | 0. |
| OREGON | X | 88. | 19. | 88. | 19. | 0. | .173 | 0. | 0. |
| PENNSYLVANIA | III | 4364. | 926. | 4364. | 926. | 0. | 8.595 | 5. | 0. |
| RHODE ISLAND | I | 327. | 69. | 327. | 69. | 0. | .645 | 0. | 0. |
| SOUTH CAROLINA | IV | 317. | 67. | 317. | 67. | 0. | .624 | 0. | 0. |
| SOUTH DAKOTA | VIII | 205. | 44. | 205. | 44. | 0. | .405 | 0. | 0. |
| TENNESSEE | IV | 121. | 26. | 121. | 26. | 0. | .238 | 0. | 0. |
| TEXAS | VI | 1709. | 362. | 1708. | 362. | 0. | 3.365 | 2. | 0. |
| UTAH | VIII | 406. | 86. | 406. | 86. | 0. | .799 | 0. | 0. |
| VERMONT | I | 127. | 27. | 127. | 27. | 0. | .250 | 0. | 0. |
| VIRGINIA | III | 885. | 188. | 885. | 188. | 0. | 1.744 | 1. | 0. |
| WASHINGTON | X | 77. | 16. | 77. | 16. | 0. | .152 | 0. | 0. |
| WEST VIRGINIA | III | 114. | 24. | 114. | 24. | 0. | .225 | 0. | 0. |
| WISCONSIN | V | 423. | 90. | 423. | 90. | 0. | .833 | 1. | 0. |
| WYOMING | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| TOTALS | | 50820. | 10780. | 50820. | 10780. | 0. | 100.100 | 62. | 0. |
| REGION I | | 5755. | 1221. | 5755. | 1221. | 0. | 11.336 | 7. | 0. |
| II | | 14106. | 2992. | 14106. | 2992. | 0. | 27.784 | 17. | 0. |
| III | | 5671. | 1203. | 5671. | 1203. | 0. | 11.170 | 7. | 0. |
| IV | | 3185. | 676. | 3185. | 676. | 0. | 6.274 | 4. | 0. |
| V | | 8602. | 1825. | 8602. | 1825. | 0. | 16.943 | 10. | 0. |
| VI | | 2431. | 516. | 2431. | 516. | 0. | 4.787 | 3. | 0. |
| VII | | 710. | 151. | 710. | 151. | 0. | 1.398 | 1. | 0. |
| VIII | | 791. | 168. | 791. | 168. | 0. | 1.559 | 1. | 0. |
| IX | | 9077. | 1926. | 9077. | 1926. | 0. | 17.880 | 11. | 0. |
| X | | 492. | 104. | 492. | 104. | 0. | .969 | 1. | 0. |

### ELECTRONIC COMPONENTS MANUFACTURING
### SIC 367
### PROCESS WASTE GENERATION — PLASTICS
### 1977 State and EPA Region Totals
### (kkg/year)

| State | EPA Region | Total Waste | | Total Potentially Hazardous Waste | | Total Hazardous Constituents (Dry Wt.) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | (Wet Wt.) | (Dry Wt.) | (Wet Wt.) | (Dry Wt.) | Flammable Solvents | Heavy Metals | Fluorides | Oils |
| ALABAMA | IV | 19. | 19. | 0. | 0. | 0. | 0. | 0. | 0. |
| ALASKA | X | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| ARIZONA | IX | 56. | 56. | 0. | 0. | 0. | 0. | 0. | 0. |
| ARKANSAS | VI | 27. | 27. | 0. | 0. | 0. | 0. | 0. | 0. |
| CALIFORNIA | IX | 907. | 907. | 0. | 0. | 0. | 0. | 0. | 0. |
| COLORADO | VIII | 19. | 19. | 0. | 0. | 0. | 0. | 0. | 0. |
| CONNECTICUT | I | 124. | 124. | 0. | 0. | 0. | 0. | 0. | 0. |
| DISTRICT OF COLUMBIA | III | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| DELAWARE | III | 14. | 14. | 0. | 0. | 0. | 0. | 0. | 0. |
| FLORIDA | IV | 185. | 185. | 0. | 0. | 0. | 0. | 0. | 0. |
| GEORGIA | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| HAWAII | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| IDAHO | X | 35. | 35. | 0. | 0. | 0. | 0. | 0. | 0. |
| ILLINOIS | V | 355. | 355. | 0. | 0. | 0. | 0. | 0. | 0. |
| INDIANA | V | 204. | 204. | 0. | 0. | 0. | 0. | 0. | 0. |
| IOWA | VII | 21. | 21. | 0. | 0. | 0. | 0. | 0. | 0. |
| KANSAS | VII | 8. | 8. | 0. | 0. | 0. | 0. | 0. | 0. |
| KENTUCKY | IV | 38. | 38. | 0. | 0. | 0. | 0. | 0. | 0. |
| LOUISIANA | VI | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MAINE | I | 32. | 32. | 0. | 0. | 0. | 0. | 0. | 0. |
| MARYLAND | III | 18. | 18. | 0. | 0. | 0. | 0. | 0. | 0. |
| MASSACHUSETTS | I | 360. | 360. | 0. | 0. | 0. | 0. | 0. | 0. |
| MICHIGAN | V | 36. | 36. | 0. | 0. | 0. | 0. | 0. | 0. |
| MINNESOTA | V | 92. | 92. | 0. | 0. | 0. | 0. | 0. | 0. |
| MISSISSIPPI | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MISSOURI | VII | 22. | 22. | 0. | 0. | 0. | 0. | 0. | 0. |
| MONTANA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEBRASKA | VII | 24. | 24. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEVADA | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW HAMPSHIRE | I | 47. | 47. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW JERSEY | II | 300. | 300. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW MEXICO | VI | 35. | 35. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW YORK | II | 1196. | 1196. | 0. | 0. | 0. | 0. | 0. | 0. |
| NORTH CAROLINA | IV | 50. | 50. | 0. | 0. | 0. | 0. | 0. | 0. |
| NORTH DAKOTA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| OHIO | V | 181. | 181. | 0. | 0. | 0. | 0. | 0. | 0. |
| OKLAHOMA | VI | 15. | 15. | 0. | 0. | 0. | 0. | 0. | 0. |
| OREGON | X | 9. | 9. | 0. | 0. | 0. | 0. | 0. | 0. |
| PENNSYLVANIA | III | 463. | 463. | 0. | 0. | 0. | 0. | 0. | 0. |
| RHODE ISLAND | I | 35. | 35. | 0. | 0. | 0. | 0. | 0. | 0. |
| SOUTH CAROLINA | IV | 34. | 34. | 0. | 0. | 0. | 0. | 0. | 0. |
| SOUTH DAKOTA | VIII | 22. | 22. | 0. | 0. | 0. | 0. | 0. | 0. |
| TENNESSEE | IV | 13. | 13. | 0. | 0. | 0. | 0. | 0. | 0. |
| TEXAS | VI | 181. | 181. | 0. | 0. | 0. | 0. | 0. | 0. |
| UTAH | VIII | 43. | 43. | 0. | 0. | 0. | 0. | 0. | 0. |
| VERMONT | I | 13. | 13. | 0. | 0. | 0. | 0. | 0. | 0. |
| VIRGINIA | III | 94. | 94. | 0. | 0. | 0. | 0. | 0. | 0. |
| WASHINGTON | X | 8. | 8. | 0. | 0. | 0. | 0. | 0. | 0. |
| WEST VIRGINIA | III | 12. | 12. | 0. | 0. | 0. | 0. | 0. | 0. |
| WISCONSIN | V | 45. | 45. | 0. | 0. | 0. | 0. | 0. | 0. |
| WYOMING | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| TOTALS | | 5390. | 5390. | 0. | 0. | 0. | 0. | 0. | 0. |
| REGION I | | 610. | 610. | 0. | 0. | 0. | 0. | 0. | 0. |
| II | | 1496. | 1496. | 0. | 0. | 0. | 0. | 0. | 0. |
| III | | 601. | 601. | 0. | 0. | 0. | 0. | 0. | 0. |
| IV | | 338. | 338. | 0. | 0. | 0. | 0. | 0. | 0. |
| V | | 912. | 912. | 0. | 0. | C. | 0. | 0. | 0. |
| VI | | 258. | 258. | 0. | 0. | 0. | 0. | 0. | 0. |
| VII | | 75. | 75. | 0. | 0. | 0. | 0. | 0. | 0. |
| VIII | | 84. | 84. | 0. | 0. | 0. | 0. | 0. | 0. |
| IX | | 963. | 963. | 0. | 0. | 0. | 0. | 0. | 0. |
| X | | 52. | 52. | 0. | 0. | 0. | 0. | 0. | 0. |

## ELECTRONIC COMPONENTS MANUFACTURING
## SIC 367
## PROCESS WASTE GENERATION — LUBRICATING & HYDRAULIC OILS
## 1977 State and EPA Region Totals
## (kkg/year)

| State | EPA Region | Total Waste | | Total Potentially Hazardous Waste | | Total Hazardous Constituents (Dry Wt.) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | (Wet Wt.) | (Dry Wt.) | (Wet Wt.) | (Dry Wt.) | Flammable Solvents | Heavy Metals | Fluorides | Oils |
| ALABAMA | IV | 8. | 1. | 8. | 1. | 0. | .002 | 0. | .385 |
| ALASKA | X | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| ARIZONA | IX | 24. | 2. | 24. | 2. | 0. | .006 | 0. | 1.146 |
| ARKANSAS | VI | 11. | 1. | 11. | 1. | 0. | .003 | 0. | .550 |
| CALIFORNIA | IX | 389. | 39. | 389. | 39. | 0. | .096 | 0. | 18.659 |
| COLORADO | VIII | 8. | 1. | 8. | 1. | 0. | .002 | 0. | .393 |
| CONNECTICUT | I | 53. | 5. | 53. | 5. | 0. | .013 | 0. | 2.543 |
| DISTRICT OF COLUMBIA | III | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| DELAWARE | III | 6. | 1. | 6. | 1. | 0. | .002 | 0. | .295 |
| FLORIDA | IV | 79. | 8. | 79. | 8. | 0. | .020 | 0. | 3.812 |
| GEORGIA | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| HAWAII | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| IDAHO | X | 15. | 1. | 15. | 1. | 0. | .004 | 0. | .713 |
| ILLINOIS | V | 152. | 15. | 152. | 15. | 0. | .038 | 0. | 7.303 |
| INDIANA | V | 97. | 9. | 87. | 9. | 0. | .022 | 0. | 4.194 |
| IOWA | VII | 9. | 1. | 9. | 1. | 0. | .002 | 0. | .434 |
| KANSAS | VII | 3. | 0. | 3. | 0. | 0. | .001 | 0. | .165 |
| KENTUCKY | IV | 16. | 2. | 16. | 2. | 0. | .004 | 0. | .778 |
| LOUISIANA | VI | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MAINE | I | 14. | 1. | 14. | 1. | 0. | .003 | 0. | .664 |
| MARYLAND | III | 8. | 1. | 8. | 1. | 0. | .002 | 0. | .377 |
| MASSACHUSETTS | I | 154. | 15. | 154. | 15. | 0. | .038 | 0. | 7.398 |
| MICHIGAN | V | 15. | 2. | 15. | 2. | 0. | .004 | 0. | .732 |
| MINNESOTA | V | 39. | 4. | 39. | 4. | 0. | .010 | 0. | 1.991 |
| MISSISSIPPI | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MISSOURI | VII | 9. | 1. | 9. | 1. | 0. | .002 | 0. | .456 |
| MONTANA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEBRASKA | VII | 10. | 1. | 10. | 1. | 0. | .003 | 0. | .494 |
| NEVADA | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW HAMPSHIRE | I | 20. | 2. | 20. | 2. | 0. | .005 | 0. | .961 |
| NEW JERSEY | II | 129. | 13. | 129. | 13. | 0. | .032 | 0. | 6.174 |
| NEW MEXICO | VI | 15. | 1. | 15. | 1. | 0. | .004 | 0. | .713 |
| NEW YORK | II | 513. | 51. | 513. | 51. | 0. | .126 | 0. | 24.602 |
| NORTH CAROLINA | IV | 21. | 2. | 21. | 2. | 0. | .005 | 0. | 1.020 |
| NORTH DAKOTA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| OHIO | V | 78. | 8. | 78. | 8. | 0. | .019 | 0. | 3.725 |
| OKLAHOMA | VI | 7. | 1. | 7. | 1. | 0. | .002 | 0. | .312 |
| OREGON | X | 4. | 0. | 4. | 0. | 0. | .001 | 0. | .191 |
| PENNSYLVANIA | III | 198. | 20. | 198. | 20. | 0. | .049 | 0. | 9.520 |
| RHODE ISLAND | I | 15. | 1. | 15. | 1. | 0. | .004 | 0. | .714 |
| SOUTH CAROLINA | IV | 14. | 1. | 14. | 1. | 0. | .004 | 0. | .691 |
| SOUTH DAKOTA | VIII | 9. | 1. | 9. | 1. | 0. | .002 | 0. | .448 |
| TENNESSEE | IV | 5. | 1. | 5. | 1. | 0. | .001 | 0. | .263 |
| TEXAS | VI | 78. | 8. | 78. | 8. | 0. | .019 | 0. | 3.728 |
| UTAH | VIII | 18. | 2. | 18. | 2. | 0. | .005 | 0. | .885 |
| VERMONT | I | 6. | 1. | 6. | 1. | 0. | .001 | 0. | .277 |
| VIRGINIA | III | 40. | 4. | 40. | 4. | 0. | .010 | 0. | 1.932 |
| WASHINGTON | X | 4. | 0. | 4. | 0. | 0. | .001 | 0. | .169 |
| WEST VIRGINIA | III | 5. | 1. | 5. | 1. | 0. | .001 | 0. | .249 |
| WISCONSIN | V | 19. | 2. | 19. | 2. | 0. | .005 | 0. | .923 |
| WYOMING | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| TOTALS | | 2310. | 231. | 2310. | 231. | 0. | .570 | 0. | 110.880 |
| REGION I | | 262. | 26. | 262. | 26. | 0. | .065 | 0. | 12.557 |
| II | | 641. | 64. | 641. | 64. | 0. | .158 | 0. | 30.776 |
| III | | 258. | 26. | 258. | 26. | 0. | .064 | 0. | 12.373 |
| IV | | 145. | 14. | 145. | 14. | 0. | .036 | 0. | 6.950 |
| V | | 391. | 39. | 391. | 39. | 0. | .096 | 0. | 18.768 |
| VI | | 110. | 11. | 110. | 11. | 0. | .027 | 0. | 5.303 |
| VII | | 32. | 3. | 32. | 3. | 0. | .008 | 0. | 1.549 |
| VIII | | 36. | 4. | 36. | 4. | 0. | .009 | 0. | 1.727 |
| IX | | 413. | 41. | 413. | 41. | 0. | .102 | 0. | 19.805 |
| X | | 22. | 2. | 22. | 2. | 0. | .006 | 0. | 1.073 |

### ELECTRONIC COMPONENTS MANUFACTURING
### SIC 367
### PROCESS WASTE GENERATION — PAINT WASTES
### 1977 State and EPA Region Totals
### (kkg/year)

| State | EPA Region | Total Waste |  | Total Potentially Hazardous Waste |  | Total Hazardous Constituents (Dry Wt.) |  |  |  |
|---|---|---|---|---|---|---|---|---|---|
|  |  | (Wet Wt.) | (Dry Wt.) | (Wet Wt.) | (Dry Wt.) | Flammable Solvents | Heavy Metals | Fluorides | Oils |
| ALABAMA | IV | 1. | 1. | 1. | 1. | 0. | .000 | 0. | 0. |
| ALASKA | X | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| ARIZONA | IX | 3. | 3. | 3. | 3. | 1. | .001 | 0. | 0. |
| ARKANSAS | VI | 1. | 1. | 1. | 1. | 1. | .000 | 0. | 0. |
| CALIFORNIA | IX | 41. | 41. | 41. | 41. | 21. | .010 | 0. | 0. |
| COLORADO | VIII | 1. | 1. | 1. | 1. | 0. | .000 | 0. | 0. |
| CONNECTICUT | I | 6. | 6. | 6. | 6. | 3. | .001 | 0. | 0. |
| DISTRICT OF COLUMBIA | III | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| DELAWARE | III | 1. | 1. | 1. | 1. | 0. | .000 | 0. | 0. |
| FLORIDA | IV | 8. | 8. | 8. | 8. | 4. | .002 | 0. | 0. |
| GEORGIA | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| HAWAII | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| IDAHO | X | 2. | 2. | 2. | 2. | 1. | .000 | 0. | 0. |
| ILLINOIS | V | 16. | 16. | 16. | 16. | 8. | .004 | 0. | 0. |
| INDIANA | V | 9. | 9. | 9. | 9. | 5. | .002 | 0. | 0. |
| IOWA | VII | 1. | 1. | 1. | 1. | 0. | .000 | 0. | 0. |
| KANSAS | VII | 0. | 0. | 0. | 0. | 0. | .000 | 0. | 0. |
| KENTUCKY | IV | 2. | 2. | 2. | 2. | 1. | .000 | 0. | 0. |
| LOUISIANA | VI | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MAINE | I | 1. | 1. | 1. | 1. | 1. | .000 | 0. | 0. |
| MARYLAND | III | 1. | 1. | 1. | 1. | 0. | .000 | 0. | 0. |
| MASSACHUSETTS | I | 16. | 16. | 16. | 16. | 8. | .004 | 0. | 0. |
| MICHIGAN | V | 2. | 2. | 2. | 2. | 1. | .000 | 0. | 0. |
| MINNESOTA | V | 4. | 4. | 4. | 4. | 2. | .001 | 0. | 0. |
| MISSISSIPPI | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MISSOURI | VII | 1. | 1. | 1. | 1. | 1. | .000 | 0. | 0. |
| MONTANA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEBRASKA | VII | 1. | 1. | 1. | 1. | 1. | .000 | 0. | 0. |
| NEVADA | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW HAMPSHIRE | I | 2. | 2. | 2. | 2. | 1. | .001 | 0. | 0. |
| NEW JERSEY | II | 14. | 14. | 14. | 14. | 7. | .003 | 0. | 0. |
| NEW MEXICO | VI | 2. | 2. | 2. | 2. | 1. | .000 | 0. | 0. |
| NEW YORK | II | 55. | 55. | 55. | 55. | 27. | .014 | 0. | 0. |
| NORTH CAROLINA | IV | 2. | 2. | 2. | 2. | 1. | .001 | 0. | 0. |
| NORTH DAKOTA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| OHIO | V | 8. | 8. | 8. | 8. | 4. | .002 | 0. | 0. |
| OKLAHOMA | VI | 1. | 1. | 1. | 1. | 0. | .000 | 0. | 0. |
| OREGON | X | 0. | 0. | 0. | 0. | 0. | .000 | 0. | 0. |
| PENNSYLVANIA | III | 21. | 21. | 21. | 21. | 11. | .005 | 0. | 0. |
| RHODE ISLAND | I | 2. | 2. | 2. | 2. | 1. | .000 | 0. | 0. |
| SOUTH CAROLINA | IV | 2. | 2. | 2. | 2. | 1. | .000 | 0. | 0. |
| SOUTH DAKOTA | VIII | 1. | 1. | 1. | 1. | 0. | .000 | 0. | 0. |
| TENNESSEE | IV | 1. | 1. | 1. | 1. | 0. | .000 | 0. | 0. |
| TEXAS | VI | 8. | 8. | 8. | 8. | 4. | .002 | 0. | 0. |
| UTAH | VIII | 2. | 2. | 2. | 2. | 1. | .000 | 0. | 0. |
| VERMONT | I | 1. | 1. | 1. | 1. | 0. | .000 | 0. | 0. |
| VIRGINIA | III | 4. | 4. | 4. | 4. | 2. | .001 | 0. | 0. |
| WASHINGTON | X | 0. | 0. | 0. | 0. | 0. | .000 | 0. | 0. |
| WEST VIRGINIA | III | 1. | 1. | 1. | 1. | 0. | .000 | 0. | 0. |
| WISCONSIN | V | 2. | 2. | 2. | 2. | 1. | .001 | 0. | 0. |
| WYOMING | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| TOTALS |  | 246. | 246. | 246. | 246. | 123. | .062 | 0. | 0. |
| REGION I |  | 28. | 28. | 28. | 28. | 14. | .007 | 0. | 0. |
| II |  | 68. | 68. | 68. | 68. | 34. | .017 | 0. | 0. |
| III |  | 27. | 27. | 27. | 27. | 14. | .007 | 0. | 0. |
| IV |  | 15. | 15. | 15. | 15. | 8. | .004 | 0. | 0. |
| V |  | 42. | 42. | 42. | 42. | 21. | .010 | 0. | 0. |
| VI |  | 12. | 12. | 12. | 12. | 6. | .003 | 0. | 0. |
| VII |  | 3. | 3. | 3. | 3. | 2. | .001 | 0. | 0. |
| VIII |  | 4. | 4. | 4. | 4. | 2. | .001 | 0. | 0. |
| IX |  | 44. | 44. | 44. | 44. | 22. | .011 | 0. | 0. |
| X |  | 2. | 2. | 2. | 2. | 1. | .001 | 0. | 0. |

### ELECTRONIC COMPONENTS MANUFACTURING
### SIC 367
### PROCESS WASTE GENERATION — HALOGENATED SOLVENTS
### 1983 State and EPA Region Totals
### (kkg/year)

| State | EPA Region | Total Waste |  | Total Potentially Hazardous Waste |  | Total Hazardous Constituents (Dry Wt.) |  |  |  |
|---|---|---|---|---|---|---|---|---|---|
|  |  | (Wet Wt.) | (Dry Wt.) | (Wet Wt.) | (Dry Wt.) | Flammable Solvents | Heavy Metals | Fluorides | Oils |
| ALABAMA | IV | 70. | 70. | 32. | 32. | 0. | .000 | 0. | .007 |
| ALASKA | X | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| ARIZONA | IX | 207. | 207. | 95. | 95. | 0. | .001 | 0. | .021 |
| ARKANSAS | VI | 99. | 99. | 46. | 46. | 0. | .000 | 0. | .010 |
| CALIFORNIA | IX | 3369. | 3369. | 1555. | 1555. | 0. | .013 | 0. | .337 |
| COLORADO | VIII | 71. | 71. | 33. | 33. | 0. | .000 | 0. | .007 |
| CONNECTICUT | I | 459. | 459. | 212. | 212. | 0. | .002 | 0. | .046 |
| DISTRICT OF COLUMBIA | III | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| DELAWARE | III | 53. | 53. | 25. | 25. | 0. | .000 | 0. | .005 |
| FLORIDA | IV | 688. | 688. | 318. | 318. | 0. | .003 | 0. | .069 |
| GEORGIA | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| HAWAII | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| IDAHO | X | 129. | 129. | 59. | 59. | 0. | .000 | 0. | .013 |
| ILLINOIS | V | 1319. | 1319. | 609. | 609. | 0. | .005 | 0. | .132 |
| INDIANA | V | 757. | 757. | 349. | 349. | 0. | .003 | 0. | .076 |
| IOWA | VII | 78. | 78. | 36. | 36. | 0. | .000 | 0. | .008 |
| KANSAS | VII | 30. | 30. | 14. | 14. | 0. | .000 | 0. | .003 |
| KENTUCKY | IV | 141. | 141. | 65. | 65. | 0. | .001 | 0. | .014 |
| LOUISIANA | VI | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MAINE | I | 120. | 120. | 55. | 55. | 0. | .000 | 0. | .012 |
| MARYLAND | III | 68. | 68. | 31. | 31. | 0. | .000 | 0. | .007 |
| MASSACHUSETTS | I | 1336. | 1336. | 617. | 617. | 0. | .005 | 0. | .134 |
| MICHIGAN | V | 132. | 132. | 61. | 61. | 0. | .001 | 0. | .013 |
| MINNESOTA | V | 342. | 342. | 158. | 158. | 0. | .001 | 0. | .034 |
| MISSISSIPPI | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MISSOURI | VII | 82. | 82. | 38. | 38. | 0. | .000 | 0. | .008 |
| MONTANA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEBRASKA | VII | 89. | 89. | 41. | 41. | 0. | .000 | 0. | .009 |
| NEVADA | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW HAMPSHIRE | I | 173. | 173. | 80. | 80. | 0. | .001 | 0. | .017 |
| NEW JERSEY | II | 1115. | 1115. | 515. | 515. | 0. | .004 | 0. | .111 |
| NEW MEXICO | VI | 129. | 129. | 59. | 59. | 0. | .000 | 0. | .013 |
| NEW YORK | II | 4442. | 4442. | 2050. | 2050. | 0. | .017 | 0. | .444 |
| NORTH CAROLINA | IV | 184. | 184. | 85. | 85. | 0. | .001 | 0. | .018 |
| NORTH DAKOTA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| OHIO | V | 673. | 673. | 310. | 310. | 0. | .003 | 0. | .067 |
| OKLAHOMA | VI | 56. | 56. | 26. | 26. | 0. | .000 | 0. | .006 |
| OREGON | X | 35. | 35. | 16. | 16. | 0. | .000 | 0. | .003 |
| PENNSYLVANIA | III | 1719. | 1719. | 793. | 793. | 0. | .007 | 0. | .172 |
| RHODE ISLAND | I | 129. | 129. | 60. | 60. | 0. | .000 | 0. | .013 |
| SOUTH CAROLINA | IV | 125. | 125. | 58. | 58. | 0. | .000 | 0. | .012 |
| SOUTH DAKOTA | VIII | 81. | 81. | 37. | 37. | 0. | .000 | 0. | .008 |
| TENNESSEE | IV | 48. | 48. | 22. | 22. | 0. | .000 | 0. | .005 |
| TEXAS | VI | 673. | 673. | 311. | 311. | 0. | .003 | 0. | .067 |
| UTAH | VIII | 160. | 160. | 74. | 74. | 0. | .001 | 0. | .016 |
| VERMONT | I | 50. | 50. | 23. | 23. | 0. | .000 | 0. | .005 |
| VIRGINIA | III | 349. | 349. | 161. | 161. | 0. | .001 | 0. | .035 |
| WASHINGTON | X | 30. | 30. | 14. | 14. | 0. | .000 | 0. | .003 |
| WEST VIRGINIA | III | 45. | 45. | 21. | 21. | 0. | .000 | 0. | .005 |
| WISCONSIN | V | 167. | 167. | 77. | 77. | 0. | .001 | 0. | .017 |
| WYOMING | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| TOTALS |  | 20020. | 20020. | 9240. | 9240. | 0. | .077 | 0. | 2.002 |
| REGION I |  | 2267. | 2267. | 1046. | 1046. | 0. | .009 | 0. | .227 |
| II |  | 5557. | 5557. | 2565. | 2565. | 0. | .021 | 0. | .556 |
| III |  | 2234. | 2234. | 1031. | 1031. | 0. | .009 | 0. | .223 |
| IV |  | 1255. | 1255. | 579. | 579. | 0. | .005 | 0. | .125 |
| V |  | 3389. | 3389. | 1564. | 1564. | 0. | .013 | 0. | .339 |
| VI |  | 957. | 957. | 442. | 442. | 0. | .004 | 0. | .096 |
| VII |  | 280. | 280. | 129. | 129. | 0. | .001 | 0. | .028 |
| VIII |  | 312. | 312. | 144 | 144. | 0. | .001 | 0. | .031 |
| IX |  | 3576. | 3576. | 1650. | 1650. | 0. | .014 | 0. | .358 |
| X |  | 194. | 194. | 89. | 89. | 0. | .001 | 0. | .019 |

## ELECTRONIC COMPONENTS MANUFACTURING
## SIC 367
## PROCESS WASTE GENERATION — NON-HALOGENATED SOLVENTS
## 1983 State and EPA Region Totals
(kkg/year)

| State | EPA Region | Total Waste | | Total Potentially Hazardous Waste | | Total Hazardous Constituents (Dry Wt.) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | (Wet Wt.) | (Dry Wt.) | (Wet Wt.) | (Dry Wt.) | Flammable Solvents | Heavy Metals | Fluorides | Oils |
| ALABAMA | IV | 86. | 86. | 86. | 86. | 80. | .000 | 0. | .009 |
| ALASKA | X | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| ARIZONA | IX | 255. | 255. | 255. | 255. | 239. | .001 | 0. | .025 |
| ARKANSAS | VI | 122. | 122. | 122. | 122. | 115. | .000 | 0. | .012 |
| CALIFORNIA | IX | 4146. | 4146. | 4146. | 4146. | 3887. | .016 | 0. | .415 |
| COLORADO | VIII | 87. | 87. | 87. | 87. | 82. | .000 | 0. | .009 |
| CONNECTICUT | I | 565. | 565. | 565. | 565. | 530. | .002 | 0. | .057 |
| DISTRICT OF COLUMBIA | III | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| DELAWARE | III | 65. | 65. | 65. | 65. | 61. | .000 | 0. | .007 |
| FLORIDA | IV | 847. | 847. | 847. | 847. | 794. | .003 | 0. | .085 |
| GEORGIA | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| HAWAII | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| IDAHO | X | 158. | 158. | 158. | 158. | 148. | .001 | 0. | .016 |
| ILLINOIS | V | 1623. | 1623. | 1623. | 1623. | 1521. | .006 | 0. | .162 |
| INDIANA | V | 932. | 932. | 932. | 932. | 874. | .003 | 0. | .093 |
| IOWA | VII | 97. | 97. | 97. | 97. | 91. | .000 | 0. | .010 |
| KANSAS | VII | 37. | 37. | 37. | 37. | 34. | .000 | 0. | .004 |
| KENTUCKY | IV | 173. | 173. | 173. | 173. | 162. | .001 | 0. | .017 |
| LOUISIANA | VI | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MAINE | I | 147. | 147. | 147. | 147. | 138. | .001 | 0. | .015 |
| MARYLAND | III | 84. | 84. | 84. | 84. | 78. | .000 | 0. | .008 |
| MASSACHUSETTS | I | 1644. | 1644. | 1644. | 1644. | 1541. | .006 | 0. | .164 |
| MICHIGAN | V | 163. | 163. | 163. | 163. | 152. | .001 | 0. | .016 |
| MINNESOTA | V | 420. | 420. | 420. | 420. | 394. | .002 | 0. | .042 |
| MISSISSIPPI | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MISSOURI | VII | 101. | 101. | 101. | 101. | 95. | .000 | 0. | .010 |
| MONTANA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEBRASKA | VII | 110. | 110. | 110. | 110. | 103. | .000 | 0. | .011 |
| NEVADA | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW HAMPSHIRE | I | 214. | 214. | 214. | 214. | 200. | .001 | 0. | .021 |
| NEW JERSEY | II | 1372. | 1372. | 1372. | 1372. | 1286. | .005 | 0. | .137 |
| NEW MEXICO | VI | 158. | 158. | 158. | 158. | 148. | .001 | 0. | .016 |
| NEW YORK | II | 5467. | 5467. | 5467. | 5467. | 5125. | .021 | 0. | .547 |
| NORTH CAROLINA | IV | 227. | 227. | 227. | 227. | 213. | .001 | 0. | .023 |
| NORTH DAKOTA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| OHIO | V | 828. | 828. | 828. | 828. | 776. | .003 | 0. | .083 |
| OKLAHOMA | VI | 69. | 69. | 69. | 69. | 65. | .000 | 0. | .007 |
| OREGON | X | 43. | 43. | 43. | 43. | 40. | .000 | 0. | .004 |
| PENNSYLVANIA | III | 2116. | 2116. | 2116. | 2116. | 1983. | .008 | 0. | .212 |
| RHODE ISLAND | I | 159. | 159. | 159. | 159. | 149. | .001 | 0. | .016 |
| SOUTH CAROLINA | IV | 154. | 154. | 154. | 154. | 144. | .001 | 0. | .015 |
| SOUTH DAKOTA | VIII | 100. | 100. | 100. | 100. | 93. | .000 | 0. | .010 |
| TENNESSEE | IV | 58. | 58. | 58. | 58. | 55. | .000 | 0. | .006 |
| TEXAS | VI | 829. | 828. | 828. | 828. | 777. | .003 | 0. | .083 |
| UTAH | VIII | 197. | 197. | 197. | 197. | 184. | .001 | 0. | .020 |
| VERMONT | I | 62. | 62. | 62. | 62. | 58. | .000 | 0. | .006 |
| VIRGINIA | III | 429. | 429. | 429. | 429. | 402. | .002 | 0. | .043 |
| WASHINGTON | X | 37. | 37. | 37. | 37. | 35. | .000 | 0. | .004 |
| WEST VIRGINIA | III | 55. | 55. | 55. | 55. | 52. | .000 | 0. | .006 |
| WISCONSIN | V | 205. | 205. | 205. | 205. | 192. | .001 | 0. | .021 |
| WYOMING | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| TOTALS | | 24640. | 24640. | 24640. | 24640. | 23100. | .092 | 0. | 2.464 |
| REGION I | | 2790. | 2790. | 2790. | 2790. | 2616. | .010 | 0. | .279 |
| II | | 6839. | 6839. | 6839. | 6839. | 6412. | .026 | 0. | .684 |
| III | | 2750. | 2750. | 2750. | 2750. | 2578. | .010 | 0. | .275 |
| IV | | 1544. | 1544. | 1544. | 1544. | 1448. | .006 | 0. | .154 |
| V | | 4171. | 4171. | 4171. | 4171. | 3910. | .016 | 0. | .417 |
| VI | | 1178. | 1178. | 1178. | 1178. | 1105. | .004 | 0. | .118 |
| VII | | 344. | 344. | 344. | 344. | 323. | .001 | 0. | .034 |
| VIII | | 384. | 384. | 384. | 384. | 360. | .001 | 0. | .038 |
| IX | | 4401. | 4401. | 4401. | 4401. | 4126. | .017 | 0. | .440 |
| X | | 238. | 238. | 238. | 238. | 224. | .001 | 0. | .024 |

ELECTRONIC COMPONENTS MANUFACTURING
SIC 367
PROCESS WASTE GENERATION — WASTEWATER TREATMENT SLUDGES
1983 State and EPA Region Totals
(kkg/year)

| State | EPA Region | Total Waste | | Total Potentially Hazardous Waste | | Total Hazardous Constituents (Dry Wt.) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | (Wet Wt.) | (Dry Wt.) | (Wet Wt.) | (Dry Wt.) | Flammable Solvents | Heavy Metals | Fluorides | Oils |
| ALABAMA | IV | 246. | 54. | 246. | 54. | 0. | .482 | 0. | 0. |
| ALASKA | X | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| ARIZONA | IX | 732. | 159. | 732. | 159. | 0. | 1.432 | 1. | 0. |
| ARKANSAS | VI | 352. | 76. | 352. | 76. | 0. | .688 | 0. | 0. |
| CALIFORNIA | IX | 11921. | 2592. | 11921. | 2592. | 0. | 23.324 | 13. | 0. |
| COLORADO | VIII | 251. | 55. | 251. | 55. | 0. | .491 | 0. | 0. |
| CONNECTICUT | I | 1624. | 353. | 1624. | 353. | 0. | 3.178 | 2. | 0. |
| DISTRICT OF COLUMBIA | III | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| DELAWARE | III | 188. | 41. | 188. | 41. | 0. | .368 | 0. | 0. |
| FLORIDA | IV | 2435. | 529. | 2435. | 529. | 0. | 4.765 | 3. | 0. |
| GEORGIA | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| HAWAII | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| IDAHO | X | 455. | 99. | 455. | 99. | 0. | .891 | 0. | 0. |
| ILLINOIS | V | 4666. | 1014. | 4666. | 1014. | 0. | 9.128 | 5. | 0. |
| INDIANA | V | 2679. | 582. | 2679. | 582. | 0. | 5.242 | 3. | 0. |
| IOWA | VII | 278. | 60. | 278. | 60. | 0. | .543 | 0. | 0. |
| KANSAS | VII | 105. | 23. | 105. | 23. | 0. | .206 | 0. | 0. |
| KENTUCKY | IV | 497. | 108. | 497. | 108. | 0. | .973 | 1. | 0. |
| LOUISIANA | VI | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MAINE | I | 424. | 92. | 424. | 92. | 0. | .830 | 0. | 0. |
| MARYLAND | III | 241. | 52. | 241. | 52. | 0. | .471 | 0. | 0. |
| MASSACHUSETTS | I | 4727. | 1028. | 4727. | 1028. | 0. | 9.248 | 5. | 0. |
| MICHIGAN | V | 467. | 102. | 467. | 102. | 0. | .915 | 1. | 0. |
| MINNESOTA | V | 1208. | 263. | 1208. | 263. | 0. | 2.364 | 1. | 0. |
| MISSISSIPPI | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MISSOURI | VII | 291. | 63. | 291. | 63. | 0. | .570 | 0. | 0. |
| MONTANA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEBRASKA | VII | 315. | 69. | 315. | 69. | 0. | .617 | 0. | 0. |
| NEVADA | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW HAMPSHIRE | I | 614. | 133. | 614. | 133. | 0. | 1.201 | 1. | 0. |
| NEW JERSEY | II | 3945. | 858. | 3945. | 858. | 0. | 7.718 | 4. | 0. |
| NEW MEXICO | VI | 455. | 99. | 455. | 99. | 0. | .891 | 0. | 0. |
| NEW YORK | II | 15718. | 3417. | 15718. | 3417. | 0. | 30.752 | 17. | 0. |
| NORTH CAROLINA | IV | 652. | 142. | 652. | 142. | 0. | 1.275 | 1. | 0. |
| NORTH DAKOTA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| OHIO | V | 2380. | 517. | 2380. | 517. | 0. | 4.656 | 3. | 0. |
| OKLAHOMA | VI | 200. | 43. | 200. | 43. | 0. | .390 | 0. | 0. |
| OREGON | X | 122. | 27. | 122. | 27. | 0. | .239 | 0. | 0. |
| PENNSYLVANIA | III | 6082. | 1322. | 6082. | 1322. | 0. | 11.901 | 7. | 0. |
| RHODE ISLAND | I | 456. | 99. | 456. | 99. | 0. | .893 | 0. | 0. |
| SOUTH CAROLINA | IV | 442. | 96. | 442. | 96. | 0. | .864 | 0. | 0. |
| SOUTH DAKOTA | VIII | 286. | 62. | 286. | 62. | 0. | .560 | 0. | 0. |
| TENNESSEE | IV | 168. | 37. | 168. | 37. | 0. | .329 | 0. | 0. |
| TEXAS | VI | 2382. | 518. | 2382. | 518. | 0. | 4.659 | 3. | 0. |
| UTAH | VIII | 566. | 123. | 566. | 123. | 0. | 1.107 | 1. | 0. |
| VERMONT | I | 177. | 38. | 177. | 38. | 0. | .346 | 0. | 0. |
| VIRGINIA | III | 1234. | 268. | 1234. | 268. | 0. | 2.415 | 1. | 0. |
| WASHINGTON | X | 108. | 23. | 108. | 23. | 0. | .211 | 0. | 0. |
| WEST VIRGINIA | III | 159. | 35. | 159. | 35. | 0. | .312 | 0. | 0. |
| WISCONSIN | V | 590. | 128. | 590. | 128. | 0. | 1.154 | 1. | 0. |
| WYOMING | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| TOTALS | | 70840. | 15400. | 70840. | 15400. | 0. | 138.600 | 77. | 0. |
| REGION I | | 8022. | 1744. | 8022. | 1744. | 0. | 15.696 | 9. | 0. |
| II | | 19663. | 4274. | 19663. | 4274. | 0. | 38.470 | 21. | 0. |
| III | | 7905. | 1718. | 7905. | 1718. | 0. | 15.466 | 9. | 0. |
| IV | | 4440. | 965. | 4440. | 965. | 0. | 8.688 | 5. | 0. |
| V | | 11990. | 2607. | 11990. | 2607. | 0. | 23.459 | 13. | 0. |
| VI | | 3388. | 737. | 3388. | 737. | 0. | 6.629 | 4. | 0. |
| VII | | 990. | 215. | 990. | 215. | 0. | 1.936 | 1. | 0. |
| VIII | | 1103. | 240. | 1103. | 240. | 0. | 2.158 | 1. | 0. |
| IX | | 12653. | 2751. | 12653. | 2751. | 0. | 24.757 | 14. | 0. |
| X | | 685. | 149. | 685. | 149. | 0. | 1.341 | 1. | 0. |

## ELECTRONIC COMPONENTS MANUFACTURING
## SIC 367
## PROCESS WASTE GENERATION — PLASTICS
## 1983 State and EPA Region Totals
## (kkg/year)

| State | EPA Region | Total Waste | | Total Potentially Hazardous Waste | | Total Hazardous Constituents (Dry Wt.) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | (Wet Wt.) | (Dry Wt.) | (Wet Wt.) | (Dry Wt.) | Flammable Solvents | Heavy Metals | Fluorides | Oils |
| ALABAMA | IV | 27. | 27. | 0. | 0. | 0. | 0. | 0. | 0. |
| ALASKA | X | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| ARIZONA | IX | 80. | 80. | 0. | 0. | 0. | 0. | 0. | 0. |
| ARKANSAS | VI | 38. | 38. | 0. | 0. | 0. | 0. | 0. | 0. |
| CALIFORNIA | IX | 1296. | 1296. | 0. | 0. | 0. | 0. | 0. | 0. |
| COLORADO | VIII | 27. | 27. | 0. | 0. | 0. | 0. | 0. | 0. |
| CONNECTICUT | I | 177. | 177. | 0. | 0. | 0. | 0. | 0. | 0. |
| DISTRICT OF COLUMBIA | III | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| DELAWARE | III | 20. | 20. | 0. | 0. | 0. | 0. | 0. | 0. |
| FLORIDA | IV | 265. | 265. | 0. | 0. | 0. | 0. | 0. | 0. |
| GEORGIA | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| HAWAII | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| IDAHO | X | 49. | 49. | 0. | 0. | 0. | 0. | 0. | 0. |
| ILLINOIS | V | 507. | 507. | 0. | 0. | 0. | 0. | 0. | 0. |
| INDIANA | V | 291. | 291. | 0. | 0. | 0. | 0. | 0. | 0. |
| IOWA | VII | 30. | 30. | 0. | 0. | 0. | 0. | 0. | 0. |
| KANSAS | VII | 11. | 11. | 0. | 0. | 0. | 0. | 0. | 0. |
| KENTUCKY | IV | 54. | 54. | 0. | 0. | 0. | 0. | 0. | 0. |
| LOUISIANA | VI | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MAINE | I | 46. | 46. | 0. | 0. | 0. | 0. | 0. | 0. |
| MARYLAND | III | 26. | 26. | 0. | 0. | 0. | 0. | 0. | 0. |
| MASSACHUSETTS | I | 514. | 514. | 0. | 0. | 0. | 0. | 0. | 0. |
| MICHIGAN | V | 51. | 51. | 0. | 0. | 0. | 0. | 0. | 0. |
| MINNESOTA | V | 131. | 131. | 0. | 0. | 0. | 0. | 0. | 0. |
| MISSISSIPPI | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MISSOURI | VII | 32. | 32. | 0. | 0. | 0. | 0. | 0. | 0. |
| MONTANA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEBRASKA | VII | 34. | 34. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEVADA | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW HAMPSHIRE | I | 67. | 67. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW JERSEY | II | 429. | 429. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW MEXICO | VI | 49. | 49. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW YORK | II | 1708. | 1708. | 0. | 0. | 0. | 0. | 0. | 0. |
| NORTH CAROLINA | IV | 71. | 71. | 0. | 0. | 0. | 0. | 0. | 0. |
| NORTH DAKOTA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0 |
| OHIO | V | 259. | 259. | 0. | 0. | 0. | 0. | 0. | 0. |
| OKLAHOMA | VI | 22. | 22. | 0. | 0. | 0. | 0. | 0. | 0. |
| OREGON | X | 13. | 13. | 0. | 0. | 0. | 0. | 0. | 0. |
| PENNSYLVANIA | III | 661. | 661. | 0. | 0. | 0. | 0. | 0. | 0. |
| RHODE ISLAND | I | 50. | 50. | 0. | 0. | 0. | 0. | 0. | 0. |
| SOUTH CAROLINA | IV | 48. | 48. | 0. | 0. | 0. | 0. | 0. | 0. |
| SOUTH DAKOTA | VIII | 31. | 31. | 0. | 0. | 0. | 0. | 0. | 0. |
| TENNESSEE | IV | 18. | 18. | 0. | 0. | 0. | 0. | 0. | 0. |
| TEXAS | VI | 259. | 259. | 0. | 0. | 0. | 0. | 0. | 0. |
| UTAH | VIII | 61. | 61. | 0. | 0. | 0. | 0. | 0. | 0. |
| VERMONT | I | 19. | 19. | 0. | 0. | 0. | 0. | 0. | 0. |
| VIRGINIA | III | 134 | 134. | 0. | 0. | 0. | 0. | 0. | 0. |
| WASHINGTON | X | 12. | 12. | 0. | 0. | 0. | 0. | 0. | 0. |
| WEST VIRGINIA | III | 17. | 17. | 0. | 0. | 0. | 0. | 0. | 0. |
| WISCONSIN | V | 64. | 64. | 0. | 0. | 0. | 0. | 0. | 0. |
| WYOMING | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| TOTALS | | 7700. | 7700. | 0. | 0. | 0. | 0. | 0. | 0. |
| REGION I | | 872. | 872. | 0. | 0. | 0. | 0. | 0. | 0. |
| II | | 2137. | 2137. | 0. | 0. | 0. | 0. | 0. | 0. |
| III | | 859. | 859. | 0. | 0. | 0. | 0. | 0. | 0. |
| IV | | 483. | 483. | 0. | 0. | 0. | 0. | 0. | 0. |
| V | | 1303. | 1303. | 0. | 0. | 0. | 0. | 0. | 0. |
| VI | | 368. | 368. | 0. | 0. | 0. | 0. | 0. | 0. |
| VII | | 108. | 108. | 0. | 0. | 0. | 0. | 0. | 0. |
| VIII | | 120. | 120. | 0. | 0. | 0. | 0. | 0. | 0. |
| IX | | 1375. | 1375. | 0. | 0. | 0. | 0. | 0. | 0. |
| X | | 75. | 75. | 0. | 0. | 0. | 0. | 0. | 0. |

## ELECTRONIC COMPONENTS MANUFACTURING
## SIC 367
## PROCESS WASTE GENERATION — LUBRICATING & HYDRAULIC OILS
## 1983 State and EPA Region Totals
## (kkg/year)

| State | EPA Region | Total Waste (Wet Wt.) | Total Waste (Dry Wt.) | Total Potentially Hazardous Waste (Wet Wt.) | Total Potentially Hazardous Waste (Dry Wt.) | Total Hazardous Constituents (Dry Wt.) Flammable Solvents | Total Hazardous Constituents (Dry Wt.) Heavy Metals | Total Hazardous Constituents (Dry Wt.) Fluorides | Total Hazardous Constituents (Dry Wt.) Oils |
|---|---|---|---|---|---|---|---|---|---|
| ALABAMA | IV | 11. | 1. | 11. | 1. | 0. | .003 | 0. | .535 |
| ALASKA | X | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| ARIZONA | IX | 32. | 3. | 32. | 3. | 0. | .008 | 0. | 1.592 |
| ARKANSAS | VI | 15. | 2. | 15. | 2. | 0. | .004 | 0. | .764 |
| CALIFORNIA | IX | 518. | 52. | 518. | 52. | 0. | .132 | 0. | 25.916 |
| COLORADO | VIII | 11. | 1. | 11. | 1. | 0. | .003 | 0. | .546 |
| CONNECTICUT | I | 71. | 7. | 71. | 7. | 0. | .018 | 0. | 3.531 |
| DISTRICT OF COLUMBIA | III | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| DELAWARE | III | 8. | 1. | 8. | 1. | 0. | .002 | 0. | .409 |
| FLORIDA | IV | 106. | 11. | 106. | 11. | 0. | .027 | 0. | 5.294 |
| GEORGIA | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| HAWAII | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| IDAHO | X | 20. | 2. | 20. | 2. | 0. | .005 | 0. | .990 |
| ILLINOIS | V | 203. | 20. | 203. | 20. | 0. | .052 | 0. | 10.143 |
| INDIANA | V | 116. | 12. | 116. | 12. | 0. | .030 | 0. | 5.824 |
| IOWA | VII | 12. | 1. | 12. | 1. | 0. | .003 | 0. | .603 |
| KANSAS | VII | 5. | 0. | 5. | 0. | 0. | .001 | 0. | .229 |
| KENTUCKY | IV | 22. | 2. | 22. | 2. | 0. | .006 | 0. | 1.081 |
| LOUISIANA | VI | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MAINE | I | 18. | 2. | 18. | 2. | 0. | .005 | 0. | .922 |
| MARYLAND | III | 10. | 1. | 10. | 1. | 0. | .003 | 0. | .523 |
| MASSACHUSETTS | I | 206. | 21. | 206. | 21. | 0. | .052 | 0. | 10.276 |
| MICHIGAN | V | 20. | 2. | 20. | 2. | 0. | .005 | 0. | 1.016 |
| MINNESOTA | V | 53. | 5. | 53. | 5. | 0. | .013 | 0. | 2.627 |
| MISSISSIPPI | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MISSOURI | VII | 13. | 1. | 13. | 1. | 0. | .003 | 0. | .633 |
| MONTANA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEBRASKA | VII | 14. | 1. | 14. | 1. | 0. | .003 | 0. | .686 |
| NEVADA | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW HAMPSHIRE | I | 27. | 3. | 27. | 3. | 0. | .007 | 0. | 1.335 |
| NEW JERSEY | II | 172. | 17. | 172. | 17. | 0. | .044 | 0. | 8.576 |
| NEW MEXICO | VI | 20. | 2. | 20. | 2. | 0. | .005 | 0. | .990 |
| NEW YORK | II | 683. | 68. | 683. | 68. | 0. | .174 | 0. | 34.169 |
| NORTH CAROLINA | IV | 28. | 3. | 28. | 3. | 0. | .007 | 0. | 1.417 |
| NORTH DAKOTA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| OHIO | V | 103. | 10. | 103. | 10. | 0. | .026 | 0. | 5.174 |
| OKLAHOMA | VI | 9. | 1. | 9. | 1. | 0. | .002 | 0. | .434 |
| OREGON | X | 5. | 1. | 5. | 1. | 0. | .001 | 0. | .266 |
| PENNSYLVANIA | III | 264. | 26. | 264. | 26. | 0. | .067 | 0. | 13.223 |
| RHODE ISLAND | I | 20. | 2. | 20. | 2. | 0. | .005 | 0. | .992 |
| SOUTH CAROLINA | IV | 19. | 2. | 19. | 2. | 0. | .005 | 0. | .960 |
| SOUTH DAKOTA | VIII | 12. | 1. | 12. | 1. | 0. | .003 | 0. | .623 |
| TENNESSEE | IV | 7. | 1. | 7. | 1. | 0. | .002 | 0. | .366 |
| TEXAS | VI | 104. | 10. | 104. | 10. | 0. | .026 | 0. | 5.177 |
| UTAH | VIII | 25. | 2. | 25. | 2. | 0. | .006 | 0. | 1.230 |
| VERMONT | I | 8. | 1. | 8. | 1. | 0. | .002 | 0. | .385 |
| VIRGINIA | III | 54. | 5. | 54. | 5. | 0. | .014 | 0. | 2.683 |
| WASHINGTON | X | 5. | 0. | 5. | 0. | 0. | .001 | 0. | .234 |
| WEST VIRGINIA | III | 7. | 1. | 7. | 1. | 0. | .002 | 0. | .346 |
| WISCONSIN | V | 26. | 3. | 26. | 3. | 0. | .007 | 0. | 1.282 |
| WYOMING | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| TOTALS | | 3080. | 308. | 3080. | 308. | 0. | .785 | 0. | 154.000 |
| REGION I | | 349. | 35. | 349. | 35. | 0. | .089 | 0. | 17.440 |
| II | | 855. | 85. | 855. | 85. | 0. | .218 | 0. | 42.745 |
| III | | 344. | 34. | 344. | 34. | 0. | .088 | 0. | 17.184 |
| IV | | 193. | 19. | 193. | 19. | 0. | .049 | 0. | 9.653 |
| V | | 521. | 52. | 521. | 52. | 0. | .133 | 0. | 26.066 |
| VI | | 147. | 15. | 147. | 15. | 0. | .038 | 0. | 7.365 |
| VII | | 43. | 4. | 43. | 4. | 0. | .011 | 0. | 2.151 |
| VIII | | 48. | 5. | 48. | 5. | 0. | .012 | 0. | 2.398 |
| IX | | 550. | 55. | 550. | 55. | 0. | .140 | 0. | 27.507 |
| X | | 30. | 3. | 30. | 3. | 0. | .008 | 0. | 1.490 |

# ELECTRONIC COMPONENTS MANUFACTURING
SIC 367
PROCESS WASTE GENERATION — PAINT WASTES
1983 State and EPA Region Totals
(kkg/year)

| | | Total Waste | | Total Potentially Hazardous Waste | | Total Hazardous Constituents (Dry Wt.) | | | |
|---|---|---|---|---|---|---|---|---|---|
| State | EPA Region | (Wet Wt.) | (Dry Wt.) | (Wet Wt.) | (Dry Wt.) | Flammable Solvents | Heavy Metals | Fluorides | Oils |
| ALABAMA | IV | 1. | 1. | 1. | 1. | 1. | .000 | 0. | 0. |
| ALASKA | X | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| ARIZONA | IX | 3. | 3. | 3. | 3. | 2. | .001 | 0. | 0. |
| ARKANSAS | VI | 2. | 2. | 2. | 2. | 1. | .000 | 0. | 0. |
| CALIFORNIA | IX | 52. | 52. | 52. | 52. | 26. | .013 | 0. | 0. |
| COLORADO | VIII | 1. | 1. | 1. | 1. | 1. | .000 | 0. | 0. |
| CONNECTICUT | I | 7. | 7. | 7. | 7. | 4. | .002 | 0. | 0. |
| DISTRICT OF COLUMBIA | III | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| DELAWARE | III | 1. | 1. | 1. | 1. | 0. | .000 | 0. | 0. |
| FLORIDA | IV | 11. | 11. | 11. | 11. | 5. | .003 | 0. | 0. |
| GEORGIA | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| HAWAII | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| IDAHO | X | 2. | 2. | 2. | 2. | 1. | .000 | 0. | 0. |
| ILLINOIS | V | 20. | 20. | 20. | 20. | 10. | .005 | 0. | 0. |
| INDIANA | V | 12. | 12. | 12. | 12. | 6. | .003 | 0. | 0. |
| IOWA | VII | 1. | 1. | 1. | 1. | 1. | .000 | 0. | 0. |
| KANSAS | VII | 0. | 0. | 0. | 0. | 0. | .000 | 0. | 0. |
| KENTUCKY | IV | 2. | 2. | 2. | 2. | 1. | .001 | 0. | 0. |
| LOUISIANA | VI | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MAINE | I | 2. | 2. | 2. | 2. | 1. | .000 | 0. | 0. |
| MARYLAND | III | 1. | 1. | 1. | 1. | 1. | .000 | 0. | 0. |
| MASSACHUSETTS | I | 21. | 21. | 21. | 21. | 10. | .005 | 0. | 0. |
| MICHIGAN | V | 2. | 2. | 2. | 2. | 1. | .001 | 0. | 0. |
| MINNESOTA | V | 5. | 5. | 5. | 5. | 3. | .001 | 0. | 0. |
| MISSISSIPPI | IV | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| MISSOURI | VII | 1. | 1. | 1. | 1. | 1. | .000 | 0. | 0. |
| MONTANA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEBRASKA | VII | 1. | 1. | 1. | 1. | 1. | .000 | 0. | 0. |
| NEVADA | IX | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| NEW HAMPSHIRE | I | 3. | 3. | 3. | 3. | 1. | .001 | 0. | 0. |
| NEW JERSEY | II | 17. | 17. | 17. | 17. | 9. | .004 | 0. | 0. |
| NEW MEXICO | VI | 2. | 2. | 2. | 2. | 1. | .000 | 0. | 0. |
| NEW YORK | II | 68. | 68. | 68. | 68. | 34. | .017 | 0. | 0. |
| NORTH CAROLINA | IV | 3. | 3. | 3. | 3. | 1. | .001 | 0. | 0. |
| NORTH DAKOTA | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| OHIO | V | 10. | 10. | 10. | 10. | 5. | .003 | 0. | 0. |
| OKLAHOMA | VI | 1. | 1. | 1. | 1. | 0. | .000 | 0. | 0. |
| OREGON | X | 1. | 1. | 1. | 1. | 0. | .000 | 0. | 0. |
| PENNSYLVANIA | III | 26. | 26. | 26. | 26. | 13. | .007 | 0. | 0. |
| RHODE ISLAND | I | 2. | 2. | 2. | 2. | 1. | .000 | 0. | 0. |
| SOUTH CAROLINA | IV | 2. | 2. | 2. | 2. | 1. | .000 | 0. | 0. |
| SOUTH DAKOTA | VIII | 1. | 1. | 1. | 1. | 1. | .000 | 0. | 0. |
| TENNESSEE | IV | 1. | 1. | 1. | 1. | 0. | .000 | 0. | 0. |
| TEXAS | VI | 10. | 10. | 10. | 10. | 5. | .003 | 0. | 0. |
| UTAH | VIII | 2. | 2. | 2. | 2. | 1. | .001 | 0. | 0. |
| VERMONT | I | 1. | 1. | 1. | 1. | 0. | .000 | 0. | 0. |
| VIRGINIA | III | 5. | 5. | 5. | 5. | 3. | .001 | 0. | 0. |
| WASHINGTON | X | 0. | 0. | 0. | 0. | 0. | .000 | 0. | 0. |
| WEST VIRGINIA | III | 1. | 1. | 1. | 1. | 0. | .000 | 0. | 0. |
| WISCONSIN | V | 3. | 3. | 3. | 3. | 1. | .001 | 0. | 0. |
| WYOMING | VIII | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| TOTALS | | 308. | 308. | 308. | 308. | 154. | .077 | 0. | 0. |
| REGION I | | 35. | 35. | 35. | 35. | 17. | .009 | 0. | 0. |
| II | | 85. | 85. | 85. | 85. | 43. | .021 | 0. | 0. |
| III | | 34. | 34. | 34. | 34. | 17. | .009 | 0. | 0. |
| IV | | 19. | 19. | 19. | 19. | 10. | .005 | 0. | 0. |
| V | | 52. | 52. | 52. | 52. | 26. | .013 | 0. | 0. |
| VI | | 15. | 15. | 15. | 15. | 7. | .004 | 0. | 0. |
| VII | | 4. | 4. | 4. | 4. | 2. | .001 | 0. | 0. |
| VIII | | 5. | 5. | 5. | 5. | 2. | .001 | 0. | 0. |
| IX | | 55. | 55. | 55. | 55. | 28. | .014 | 0. | 0. |
| X | | 3. | 3. | 3. | 3. | 1. | .001 | 0. | 0. |

# APPENDIX C

# METHODOLOGY

## SELECTION OF PLANTS FOR SURVEY

The following objectives and criteria for selection of plants to be surveyed for this study were defined at its initiation:

- The goal for total number of plants to be surveyed was 30.
- The first 25 plants visited were to be chosen to be as representative of the product areas and geographic distribution of the industry as possible with the stipulation that large plants were preferred to maximize the amount of information obtainable per visit. Regional or product area problems recognized during the first 25 visits would be selectively investigated further by the remaining five visits.
- The geographic distribution of the first 25 plants surveyed would be proportional to the total number of electronic component plants in each of the four Department of Commerce Census Regions based upon 1972 data [ 5] as shown below:

| Census Region | Number of Industry Plants | Survey Goal-Number of Plants |
|---|---|---|
| Northeast | 1107 | 10 |
| North Central | 602 | 5 |
| South | 364 | 3 |
| West | 782 | 7 |
| | 2855 | 25 |

- The product area distribution of the first 25 plants surveyed would be proportional to the industry value of shipments in each of the nine four-digit SIC's based upon 1972 Department of Census Data as shown below:

| SIC | Value of Industry Shipments ($ mil) | Survey Goal-Number of Plants |
|---|---|---|
| 3671 | 230.4 | |
| 3672 | 696.4 | 4 |
| 3673 | 479.3 | |
| 3674 | 2686.9 | 8 |
| 3675 | 445.8 | 1 |
| 3676 | 372.2 | 1 |
| 3677 | 353.5 | 1 |
| 3678 | 491.9 | 2 |
| 3679 | 3041.6 | 8 |
| | 8798.1 | 25 |

SIC's 3671, 3672 and 3673 were initially grouped together on the basis of available information [ 7 ] which suggested that manufacturing processes and materials were similar for the three product areas.

Names, addresses, phone numbers, products SIC (however, see Section II) and, occasionally, value of shipments for electronic component manufacturers were available from Dun and Bradstreet Marketing Services for Manufacturers, 1975 [ 6 ]. Management personnel of plants selected from this list according to the above criteria were contacted to request their voluntary cooperation in this study. Written requests for their cooperation including information about the study and the types of information sought were sent to companies that indicated a willingness to participate. The distribution of the plants which were visited or that provided sufficient information for analysis (one company rejected a plant visit but supplied pertinent information by mail) is presented in Table III-4. Reticence of a majority of companies contacted to participate plus limited time allocated to plant selection resulted in an inability to acquire even the planned 25 initial visits. Nevertheless, those plants visited provide satisfactory representation of the industry. The plants account for 0.92 percent of the 2500 industry plants estimated to be in operation in 1975 [10]. However, because of the bias toward large plants, 3.6 percent of the 1975 value of industry shipments is represented by these plants. At the same time, small plants are included in those visited. Seven of the 23 participating plants had annual sales less than the industry average per plant of $4 million per year.

## TRADE ASSOCIATION CONTACTS

In an effort to include as much industry participation as possible, trade associations which represent electronic component manufactures were sought. Eight trade associations listed under "Electricity and Electronics" in the 1974 volume of National Trade and Professional Associations of the United States and Labor Unions [38] were contacted. Three other associations suggested by the initial contacts were also conducted. Only one trade association, the Electronic Industries Association, indicated that they represent electronic components manufactures. Approximately 200 electronic components manufactures support this association. EIA provided a copy of its membership list and some technical information phosphors used in cathode ray tubes.

## PLANT VISITS

A standard interview format was developed for use in obraining and recording plant information. The form is shown at the end of this Appendix. The plant visits were generally limited to four hours or less and, depending upon the consultant's judgement, included three phases: (1) the company representative(s) was interviewed to acquire information on the size, product and operation of the plant; (2) a tour of the operation of the plant facilities was requested emphasizing raw materials used, process flow, waste generation by the various manufacturing processes, and waste handling and disposal methods; and (3) when the company representative could not estimate waste volumes, this information was sought in waste contractor billing records.

## LABORATORY ANALYSIS OF WASTES

A total of 16 process waste samples were collected from manufacturing plants. Analytical methodology is described below.

Analytical result for 12 of these samples has been reported in Section III - Waste Characteristics. The remaining four samples were not discussed in Section III because of reasons explained in description of the wastes below. Results of the analyses is reported in Table C-1.

Sample 1 - This was an untreated wastewater sample from a semiconductor manufacturing plant. The sample was collected primarily to determine the amount of fluoride wasted from silicon etching with hydrofluoric acid. The 440 mg/l of fluoride is quite high and would be expected to be quite harmful to aquatic biota if discharged directly to a stream. The wastewater,

# TABLE C-1

## CHEMICAL ANALYSIS OF MISCELLANEOUS WASTE SAMPLES

| Sample | % Drying Loss 103°C | % Ignition Loss 550°C | % Solids 550°C | pH | Oil & Grease | % $H_2O$ | Flash Point °F | T.C.E. % | Cd | Cr | Cu | Fe | Pb (mg/kg) | Zn | Ni | $F^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | Water leached | | | | |
| 1 | 99.99 | 0.01 | 0.01 | 2.4 | | 99 | N.F. | | <0.02 | <0.02 | 0.02 | 0.8 | <1.0 | 0.02 | | 440 |
| | | | | | | | | | | | | As received | | | | |
| | | | | | | | | | <0.01 | 0.05 | 0.05 | 0.7 | <0.3 | 0.3 | | |
| | | | | | | | | | | | | Water leached | | | | |
| 2 | 7.56 | 90.49 | 1.95 | 12.0 | 10,275 | - | 170 | | 1.4 | 1.6 | 0.6 | 12 | <1.0 | 1.5 | 0.4 | |
| | | | | | | | | | | | | As received | | | | |
| | | | | | | | | | 0.2 | 0.8 | 0.5 | 4 | <0.4 | 0.8 | 0.6 | |
| 3 | | | | | | | | | 70 ug/$in^2$ | 19 ug/$in^2$ | 1 ug/$in^2$ | 640 ug/$in^2$ | 12,500 ug/$in^2$ | 8000 ug/$in^2$ | | |
| | | | | | | | | | | | | As received | | | | |
| 4 | | | | | | | | | <1.0 | 0.1 | 0.6 | <0.5 | <2 | 0.6 | | |

however, is discharged to a municipal wastewater treatment plant. Contraction of fluorides in the treatment plants effluent is not known. Except for a small amount of chromium in the wastewater, heavy metal concentrations are very low.

Sample 2 - This sample was an alkaline cleaning solution collected from an area of an electronic components plant where another related product was being made. Cadmium and chromium concentrations in this waste reflect its use with various metal products.

Samples 3 and 4 were parts of television picture tubes that broke during remanufacturing operations. Sample 3 was fractured glass from a screen. The sample was leached in 1:1 nitric acid and results are expressed in terms of micrograms of metal leached per square inch of surface. The large amount of lead can be attributed to the frit used to fuse glass pieces together. The zinc and probably the cadmium probably originated in the screen phosphors. Sample 4 was a piece of resin that is applied to some tubes to reduce safety hazards from implosion. Again, the sample was leached in acid. Results are in terms of mg/kg as for most other samples. The relatively small amount of chromium in this sample probably is a residue from acid cleaning of the tube during original manufacture.

Analytical methods are described below:

## Flash Point

A Setaflash Tester (closed cup, range 50-225°F) model OISF was used in all flash point measurements. This instrument has been accepted by the American Society for Testing and Materials (ASTM Method D-3278-73) as well as the Department of Transportation. All values reported were to the nearest degree Fahrenheit except where no flash was observed (upper limit of detection is 225°F).

## Oil and Grease (Hexane Extractables)

The oil and grease content of the sludge samples was determined by first drying a portion (20 g) of the sample with magnesium sulfate (monohydrate), followed by grinding into a dry powder. The resulting powder was then extracted in a soxhlet apparatus using 150 ml of hexane as the extracting solvent (four hours at 20 cycles/hours). The solvent, containing the extracted oil and grease, was then evaporated at 45°C in a beaker. After dessicating, the beaker was weighed and the oil and grease (hexane extractable) content calculated (reported as mg/kg).

The oil and grease content of the liquid samples were determined by first acidifying a portion of the sample with HCl to a pH of 1. The solid and/or viscous grease was then separated from the liquid by filtration (Whatman #40 filter paper containing one gram of filter aid). The filter paper, containing the oil and grease, was then extracted as described above for the sludge samples in a soxhlet apparatus using 150 ml of hexane. The oil and grease content was reported as mg/kg (hexane extractable). (Lower detection limit 25 mg/l). Reference: Standard Methods for the Examination of Water and Wastewater, 13th Ed., Method 209C, p. 412, Method 209A, p. 409, APHA, AWWA, WPCF, 1971.

## Metals (Cd, Cr, Cu, Fe, Pb, and Zn)

Samples for metal analyses were prepared for atomic absorption spectroscopy by two procedures. First, the samples were weighed into

250 ml Erlenmyer flasks and twice the samples' weight of distilled water was added. The flasks were sealed and placed on a Burrell Model 75 wrist action shaker and agitated for 8 hours. The samples were then centrifuged and filtered through 0.45 micron filters to remove particulate matter. (pH and specific conductance of the filtrates were measured.) The filtrates were acidified with $HNO_3$ and evaporated to dryness on a hot plate. The residues were dissolved with HCl and diluted to a known volume with distilled water. The metals were then determined by atomic absorption spectroscopy as described in Manual of Methods for Chemical Analysis of Water and Wastes, U.S. EPA, 1974.

Second, the ignited solids obtained from the percent solids at 550°C were treated with $HNO_3$ and evaporated to dryness. The residues were leached with HCl and diluted to known volumes with distilled water. The metals were determined as above.

The ranges of detection limits in ppm were as follows:

| | |
|---|---|
| Cd | 0.02 - 0.2 |
| Cr | 0.02 - 0.2 |
| Cu | 0.06 - 0.2 |
| Fe | 0.08 - 1.0 |
| Pb | 0.5 - 10.0 |
| Zn | 0.02 - 0.2 |
| Ni | 0.1 |
| Mn | 0.04 |

Fluoride

The fluoride content was determined by leaching 25 grams of sample with 50 ml of distilled water. After filtering, the filtrate was analyzed for fluoride by adding SPADN[5] reagent and comparing the spectrophotometrically measured absorbance with standards. The results were reported as leachable fluoride on an mg/kg of sample basis. (Lower limit of detection - 0.1 mg/kg). Reference: Standard Methods for the Examination of Water and Wastewater, 13th Ed., Method 121C, p. 174, APHA, AWWA, WPCF, 1971.

### pH

The pH of the liquid sample, as well as the leachates obtained from leaching the solid samples (see metal analysis methodology) was determined using an Analytical Measurements digital pH meter and a combination electrode. All measurements were made at ambient temperature and reported to the nearest 0.1 pH units. The meter was standardized against standard buffer solutions at pH 4, 7 and 10.

### Drying Loss of Solids at 103°C

Samples were weighed into tared dishes previously ignited at 550°C. The dishes were placed in a drying overn at 103°C and dried to a constant weight. (Lower limit of detection 0.01%.)

### Ignition Loss of Solids at 550°C

The weighed dishes from the drying loss at 103°C were placed in a muffle furnace at 550°C and ignited to a constant weight. The weight loss from 103°C to 550°C was calculated as ignition loss at 550°C. (Lower limit of detection - 0.01%.)

### Solids at 550°C

The residue remaining after ignition at 550°C was calculated as solids at 550°C. (Lower limit of detection - 0.01%.) 1970 Annual Book of ASTM Standards, Part 21.

## Water

Water was determined on the aqueous-organic mixtures using the Karl Fisher Titration with visual end point. The Karl Fischer Titration for water is represented by the simplified equation:

$(I_2 + SO_2 + CH_3OH + 3\ \text{Pyridine}) + H_2O \quad (2\ \text{Pyridine}\ H^+\ 1^- +$

$\text{Pyridine}\ HOSO_2OCU_3)$

(Karl Fischer Reagent)    End Product with $H_2O$

Samples were weighed into $CH_3OH$, which had been titrated free of water, and standard Karl Fischer Reagent was added to a visual end point. Colored $I_2$ is consumed in the reaction with water allowing end point detection. (Lower limit of detection - 0.2%.) Chemical Analysis, H. A. Laitinen, 1960, p. 421 FF.

## Trichloroethylene

The trichloroethylene (M.W. 131.4, B.P. 87°C) content of those samples suspected of containing a significant amount was determined according to the following procedure:

1. A mixture containing 33% toluene, 33% methanol, and 33% sample was prepared and distilled. The distillate boiling over at up to 105°C was collected and analyzed by gas chromotography.

2. One microliter of distillate was injected into a Varian series 280 gas chromatograph, isothermally operated at 70°C, using a flame ionization detector and a 1/4" x 6' stainless steel column packed with 15% Carbowax - TPA on 80/100 Chromosorb W. The chromatograph was operated in conjunction with a strip chart recorder and an Autolab integrator.

3. Calculation of the percent of trichloroethylene in the unknown samples were made by comparison with standard trichloroethylene solutions and the internal methanol standard present in each of the samples distilled.

Results were reported as % trichloroethylene. (Lower limit of detection - 0.1%.) References: Standard Methods for the Examination of Water and Wastewater, 13th Ed., Method 113A, p. 100, APHA, AWWA, WPCF, 1971 and H. McNair, E. Bonelli, Basic Gas Chromatography, Consolidated Publishers, California, p. 111, 1967.

Precision and Accuracy

Precision and accuracy data collected in-house on methods used to analyse these samples exceed the precision and accuracy data in Manual of Methods for Chemical Analysis of Water and Waste, U.S. EPA, 1974.

Precision and accuracy data were not determined on these samples for the following reasons:

1. The samples were of such great variety that replication, to have been meaningful, would have required that every sample be included. The work involved would have been beyond the scope of this program.

2. The sample size was insufficient in some cases.

3. Accuracy data could not be obtained on the water leached analyses because pH could not be controlled. Control of pH is necessary to prevent precipitation of elements added to obtain accuracy data.

4. Samples collected were non-homogeneous grab samples and do not necessarily represent long term conditions.

WAPORA, Inc.
Contract No. 68-01-3193

## Assessment of Industrial Hazardous Waste Practices
## Electronic Components Manufacturing - SIC 367

### Plant Survey Report

## I. GENERAL INFORMATION

Company Name

Plant Address Zip

Contact(s) Telephone

Date of Visit Survey Team

EPA Representative

Total Number of Employees at Plant __________

Plant Age

Recent Modifications to Plant or Environmental Controls ______________________
______________________________________________________________________
______________________________________________________________________

Planned Modifications to Plant or Environmental Controls ______________________
______________________________________________________________________
______________________________________________________________________

Articles on Waste Treatment or Process Modifications ______________________
______________________________________________________________________

Previous Sample Analysis of Waste Streams

## II. PLANT PRODUCTION

| Product | 4 digit SIC | Number/yr | Sales/yr | # Employees |
|---|---|---|---|---|
| | | | | |

## III. PRINCIPAL AND WASTE SIGNIFICANT RAW MATERIALS

| Material | Product or Process Used For: | Usage Rate | Disposition | |
|---|---|---|---|---|
| | | | Product | Waste Stream |
| | | | | |

Composition of Trade-Named Materials:

| Trade Name | Composition | Composition Data Acquired From |
|---|---|---|

IV. MANUFACTURING PROCESSES - Identify specific processes involved in manufacturing operations within the categories underlined below. Cross out those processes listed below if not present in plant. Refer to inverviewers instruction sheet for list of processes.

| | Process Description | Product SIC(s) | Process Area (sq.ft) | No. Empl. | Materials Added or Used | | Waste Stream | | Disposition |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Type | Rate | Components | Generation Rate | |
| Castings & Molding | | | | | | | | | |
| Mechanical Material Removal | | | | | | | | | |
| Material Forming | | | | | | | | | |
| Refining | | | | | | | | | |
| Plastic Molding | | | | | | | | | |

IV. MANUFACTURING PROCESSES - (Continued)

|  | Process Description | Product SIC(s) | Process Area (sq.ft) | No. Empl. | Materials Added or Used |  | Waste Stream |  |  |
|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  | Type | Rate | Components | Generation Rate | Disposition |
| **Physical Property Modification** |  |  |  |  |  |  |  |  |  |
| **Assembly** |  |  |  |  |  |  |  |  |  |
| **Material Coating** |  |  |  |  |  |  |  |  |  |
| Painting |  |  |  |  |  |  |  |  |  |
| Galvanizing |  |  |  |  |  |  |  |  |  |
| Dipping |  |  |  |  |  |  |  |  |  |
| Vacuum Metalizing |  |  |  |  |  |  |  |  |  |
| Vacuum Coating |  |  |  |  |  |  |  |  |  |
| **Air Pollution Control** |  |  |  |  |  |  |  |  |  |

IV. MANUFACTURING PROCESSES - (Continued)

| Process Description | Product SIC(s) | Process Area (sq.ft) | No. Empl. | Materials Added or Used | | Waste Stream | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Type | Rate | Components | Generation Rate | Disposition |
| Chemical - Electro-Chemical Operations | | | | | | | | |
| Conversion Coating | | | | | | | | |
| Chemical Machining | | | | | | | | |
| Electroplating | | | | | | | | |
| Electroless Plating | | | | | | | | |
| Immersion Plating | | | | | | | | |
| Etching - Metals | | | | | | | | |
| Etching - Non Metals | | | | | | | | |
| Pickling | | | | | | | | |
| Stripping | | | | | | | | |
| Other | | | | | | | | |
| Other | | | | | | | | |

V. **WASTE STREAM DATA** - List specific waste streams below starting with process wastes and following through to residue and vehicle disposal. Indicate combination and separation of waste streams. Include wastewater treatment sludges.

| | Waste Stream | From | To | Possible Hazardous Components | Generation Rate | Handling, Treatment Disposal Costs |
|---|---|---|---|---|---|---|
| a) | | | | | | |
| | | | | | | |
| b) | | | | | | |
| | | | | | | |
| c) | | | | | | |
| | | | | | | |
| d) | | | | | | |
| | | | | | | |
| e) | | | | | | |
| | | | | | | |
| f) | | | | | | |
| | | | | | | |
| g) | | | | | | |
| | | | | | | |

## V. WASTE STREAM DATA - (Continued)

Contractor Information

| | Name | Address | Location | Service | Phone Number |
|---|---|---|---|---|---|
| Contractor #1 | | | | | |
| Contractor #2 | | | | | |
| Contractor #3 | | | | | |

## VI. WASTE SAMPLING DATA

| | Sample #1 | Sample #2 | Sample #3 |
|---|---|---|---|
| Waste Stream Description and Designation (from Section V) | | | |
| Date/Time Sampled | | | |
| Sample Description. Volume of sample, color, composition, flow or size at source, etc. | | | |
| Preservation Required | | | |
| Container Type and Size | | | |
| Identification Number | | | |
| Recommended Analysis | | | |
| Analysis Performed/Results | | | |

VII. COST DATA - For appropriate waste streams identified in Section V, indicate source and dependability of data, any actions taken to verify data and whatever breakdown of data possible according to capital, land, labor, equipment, debt servicing and contractor service costs.

VIII. PROCESS AND WASTE FLOW DIAGRAM - Using data from Sections III, IV and V present a material flow diagram for each SIC represented in plant.

# APPENDIX D

## PRIVATE WASTE CONTRACTORS AND SERVICE ORGANIZATIONS

| | EPA REGION | TYPE OF FACILITY |
|---|---|---|
| Montvale Laboratories<br>270 Talbot Avenue<br>Dorchester, Mass. | I | Secured Landfill |
| Eastern Smelting & Refining Corporation<br>Lynn, Mass. | I | Metal Recovery |
| Davis Refuse Co., Inc.<br>127 Orchard Street<br>Stamford, Conn | I | Unknown |
| Turnpike Furnace Co.<br>127 Tunnix Hill Road<br>Fairfield, Conn. | I | Incineration |
| W. R. Archer<br>1034 Garden Road<br>Orange, Conn | I | Landfill |
| Axton-Cross<br>Poughkeepsie, NY | II | Unknown |
| Dachenhausen<br>5083 Kings Highway<br>Saugerties, NY | II | Landfill |
| Pollution Control Corp.<br>Oswego, NY | II | Incineration |
| Wayne Scrap<br>Lyons, NY | II | Metal Recovery |
| Chem-Trol Pollution Services, Inc.<br>P. O. Box 200<br>Model City, NY | II | Secured landfill;<br>Incineration |
| Chemical Waste Disp. Co.<br>42-14 19th Avenue<br>Astoria, NY | II | Metal Recovery |
| L&M Steel Drum<br>54 Van Courtland Pk. Ave.<br>Yonkers, NY | II | Solvent Recovery |

APPENDIX D
(Continued)

| | EPA REGION | TYPE OF FACILITY |
|---|---|---|
| Auburn Container Co.<br>Auburn, NY | II | Landfill |
| Buffalo Solvents<br>Tonawanda, NY | II | Solvent Recovery |
| Simon Wrecking Co., Inc.<br>P. O. Box 1184<br>2525 Trenton Avenue<br>Williamsport, PA | III | Incineration |
| Industrial Salvage Co.<br>294 Depot Station<br>St. Marys, PA | III | Metal Recovery |
| Prince William Trash Service<br>Manassas, VA | III | Landfill |
| Conservit<br>Hagerstown, MD | III | Metal Recovery |
| Maryland Metals & Residue<br>Baltimore, MD | III | Metal Recovery |
| Rollins-Purle, Inc.<br>P. O. Box 2349<br>Wilmington, Delaware | III | Unknown |
| Erie Disposal Co.<br>1754 W. 16th Street<br>Erie, PA | III | Landfill |
| Fox Disposal<br>Hagerstown, MD | III | Landfill |
| Dekalb County Sanitation Department<br>Beaufort Highway<br>Shambly, GA | IV | Landfill |
| F&J Disposal<br>1120 Helvetia Drive<br>Highland, Illinois | V | Landfill |

## APPENDIX
(Continued)

| | EPA REGION | TYPE OF FACILITY |
|---|---|---|
| Santow Brothers<br>3208 S. Shields<br>Chicago, Ill. | V | Metal Recovery |
| Waste Management of Ill.<br>P. O. Box 563<br>Palos Heights, Ill. | V | Secured Landfill |
| Superior Co.<br>Ft. Wayne, Indiana | V | Metal Recovery |
| Active Disposal<br>2708 South 9th Avenue<br>Broadview, Illinois | V | Landfill |
| Chemical Waste Management<br>P. O. Box 21F<br>Calumet City, Illinois | V | Oil Recovery |
| Roberts Sewer Service<br>Ottawa, Ohio | V | Landfill |
| Walker Metallurgical<br>Detroit, Michigan | V | Metal Recovery |
| Newland Hauling<br>Ottawa, Ohio | V | Landfill |
| SCA Services<br>1726 Main Street<br>Kansas City, MO | VII | Landfill |
| Copper State Chemicals<br>748 E. 16th Street<br>Tucson, Arizona | IX | Solvent Recovery |
| Ken's Oil<br>11622 Magee Land<br>Garden Grove, California | IX | Secured Landfill |
| Baron-Blakslee<br>9445 Ann Street<br>Sante Fe Springs, California | IX | Solvent Recovery |
| Phenix Labs<br>1310 W. Colling Avenue<br>Orange, California | IX | Solvent Recovery |

APPENDIX
(Continued)

| | EPA REGION | TYPE OF FACILITY |
|---|---|---|
| Chatham Chemicals Co.<br>P. O. Box 1801<br>Escondido, California | IX | Solvent Recovery |
| Nuclear Engineering Co.<br>Box 156<br>San Ramon, California | IX | Secured Landfill |
| Miller & Gibson<br>10408 Bret Avenue<br>Cupertino, California | IX | Secured Landfill |
| Oscar E. Erickson, Co.<br>249 Tewksbury Avenue<br>Richmond, California | IX | Unknown |
| Southwest Solvents<br>3411 W. Buchanon<br>Phoenix, Arizona | IX | Solvent Recovery |
| Romic Chemical Corporation<br>2081 Bay Road<br>Palo Alto, California | IX | Solvent Recovery |
| Jos Levin and Son<br>2225 3rd Street<br>San Francisco, Calif. | IX | Metal Recovery |

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